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Carnegie Mellon University
Software Engineering Institute

A Mature Profession of Software Engineering

Gary Ford, Norman E. Gibbs

January 1996

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Gary Ford

Norman E. Gibbs

Professional Infrastructure Team

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Software Engineering Institute
Carnegie Mellon University
Pittsburgh, Pennsylvania 15213

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SEI Joint Program Office
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5 Eglin Street
Hanscom AFB, MA 01731-2116

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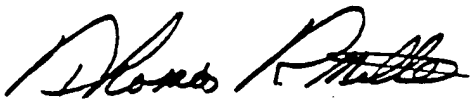

Thomas R. Miller, Lt Col, USAF
SEI Joint Program Office

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A Mature Profession of Software Engineering

Abstract: A model is presented that allows the characterization of the maturity of a profession in terms of eight infrastructure components: initial professional education, accreditation, skills development, certification, licensing, professional development, a code of ethics, and a professional society. Several mature professions are examined to provide examples of the nature of these components. The current states of the components of software engineering are described, and predictions are made for the evolution of those components as the profession matures.

Introduction

Software engineering is a relatively young profession, and almost everyone would consider it to be immature. In 1995, the SEI undertook an effort to characterize and model the evolution and maturation of professions in order to understand how the software engineering profession might develop. It was our belief that an appropriate vision of a future, mature profession of software engineering would help guide current activities to accelerate achieving the vision. This report describes that future vision.

The report contains three chapters. Chapter 1 defines basic terms (such as "profession") and develops a model by which the maturity of a profession can be characterized. Chapter 2 explores and validates the model by applying it to several common professions. Chapter 3 then uses the model to describe the characteristics of a mature software engineering profession and suggests how that vision might be achieved.

Throughout the report, examples of characteristics of common professions (such as medicine, law, and engineering) are used to suggest how the comparable characteristics of the software engineering profession might evolve. The details of those examples appear in the appendices.

1 A Model to Characterize a Mature Profession

What is a profession? What is a mature profession?

Each of us probably has some intuitive ideas that answer these questions. We believe, however, that good answers to these questions require an explicit model of a profession. With a good model, we can more precisely describe what constitutes a profession and how a profession evolves from its initial stages to maturity. We can also use a model to predict how a new profession such as software engineering is likely to evolve.

This chapter surveys definitions of the term *profession,* identifies common themes in those definitions, introduces a model of a profession as a set of components, and then develops a way of characterizing the maturity of a profession in terms of the maturity of the components.

1.1 Definitions of "Profession"

The term *profession* is fundamental to our discussion, so we begin by examining published definitions of this term.

Webster's Ninth New Collegiate Dictionary [Webster 83] gives this definition:

> **profession** ... **4 a :** a calling requiring specialized knowledge and often long and intensive academic preparation **b :** a principal calling, vocation, or employment **c :** the whole body of persons engaged in a calling.

It also gives these definitions of the related terms *professional* and *professionalism:*

> **professional** ... **1 a :** of, relating to, or characteristic of a profession **b :** engaged in one of the learned professions **c :** characterized by or conforming to the technical or ethical standards of a profession ...
>
> **professionalism** ... **1 :** the conduct, aims, or qualities that characterize or mark a profession or a professional person ...

The International Encyclopedia of the Social Sciences [IESS 68] states that the core criteria for a profession are

> (a) a requirement of formal training accompanied by some institutional mode of validating both the adequacy of the training and the competence of trained individuals
>
> (b) a requirement that skills in some form of the use of the training must be developed
>
> (c) some means of making sure that such competence will be put to socially responsible uses

The United States has adopted labor laws and regulations whose interpretation requires an understanding of what is meant by a "professional" employee, as contrasted with other kinds of employees. Toward that end, the US Code of Federal Regulations [29 CFR Sec. 541.3] defines an employee "employed in a professional capacity" as one

> (a) Whose primary duty consists of the performance of:
>
> > (1) Work requiring knowledge of an advanced type in a field of science or learning customarily acquired by a prolonged course of specialized intellectual instruction and study, as distinguished from a general academic education and from an apprenticeship, and from training in the performance of routine mental, manual, or physical processes, or
> >
> > (2) Work that is original and creative in character in a recognized field of artistic endeavor (as opposed to work which can be produced by a person endowed with general manual or intellectual ability and training), and the result of which depends primarily on the invention, imagination, or talent of the employee, ...
>
> (b) Whose work requires the consistent exercise of discretion and judgment in its performance; and
>
> (c) Whose work is predominantly intellectual and varied in character (as opposed to routine mental, manual, mechanical, or physical work) and is of such character that the output produced or the result accomplished cannot be standardized in relation to a given period of time; ...

1.2 A Model of a Profession

The definitions above suggest that, at the highest level, a profession involves a set of persons using knowledge to engage in a set of activities. In this report we use the term *professionals* to denote that set of persons and the term *professional practice* to denote that set of activities.

Looking below that highest level, we find that the definitions suggest that there are several other components of a profession.

The definitions all imply that professionals have completed an intensive course of specialized study. In this report we use the term *initial professional education* to denote the portion of that course of study that is completed prior to engaging in professional practice. We use the term *professional development* to denote additional study undertaken after beginning professional practice.

The definitions suggest that professionals have not only acquired knowledge (through initial professional education), but that they have also acquired a level of skill in applying that knowledge. Some professions have highly structured activities to allow individuals to acquire those skills. We use the term *skills development* for those activities.

Professions must have ways to assess and assure the adequacy of education and training and the competence of individual professionals. Common forms of these components are *accreditation* of professional education programs and *certification* and *licensing* of individuals.

Professions must have ways to assure that the knowledge and skills of individual professionals are put to socially responsible uses. One common form of this component is a *code of ethics*. In some cases, this component may be called a *code of practice* or a *code of conduct*.

Finally, although not explicitly mentioned in the definitions, there is an implication that a profession has an identity—that the professionals see themselves as part of community of like-minded individuals who care about the quality of their professional practice. This identity usually manifests itself in the form of a *professional society*. Most professionals belong to the society, which, mostly through volunteer efforts, promotes the development and interactions of the other components of the profession.

To summarize, we have modeled a profession at two levels, with each level consisting of components. We call these levels the *practitioner level* and the *infrastructure level.* Figure 1.1 lists the components at each level.

Practitioner Level	**Infrastructure Level**
Professionals	Initial Professional Education
Knowledge	Accreditation
Professional Practice	Skills Development
	Certification
	Licensing
	Professional Development
	Code of Ethics
	Professional Society

Figure 1.1: Levels and Components of the Model of a Profession

Figure 1.2 shows the infrastructure-level components of a profession and suggests a typical path for a person choosing to enter that profession. In the figure, the boxes represent the activity and organizational components, and the magnifying glasses represent quality assurance components.

The aspiring professional first undertakes initial professional education (the education that precedes the first day on the job; usually provided by a university); the quality of a professional degree program is assured by accreditation. To become a professional, he or she must develop skill in the application of that education (through university co-op programs, on-the-job training, apprenticeships, internships, or other means). Certification and/or licensing assures the competence of the individual to enter professional practice. Throughout practice, there are periods of professional development, possibly resulting in recertification or relicensing. The profession assures that its practitioners behave in a responsible manner by defining a code of ethics. A professional society helps assure that all the other components interact appropriately.

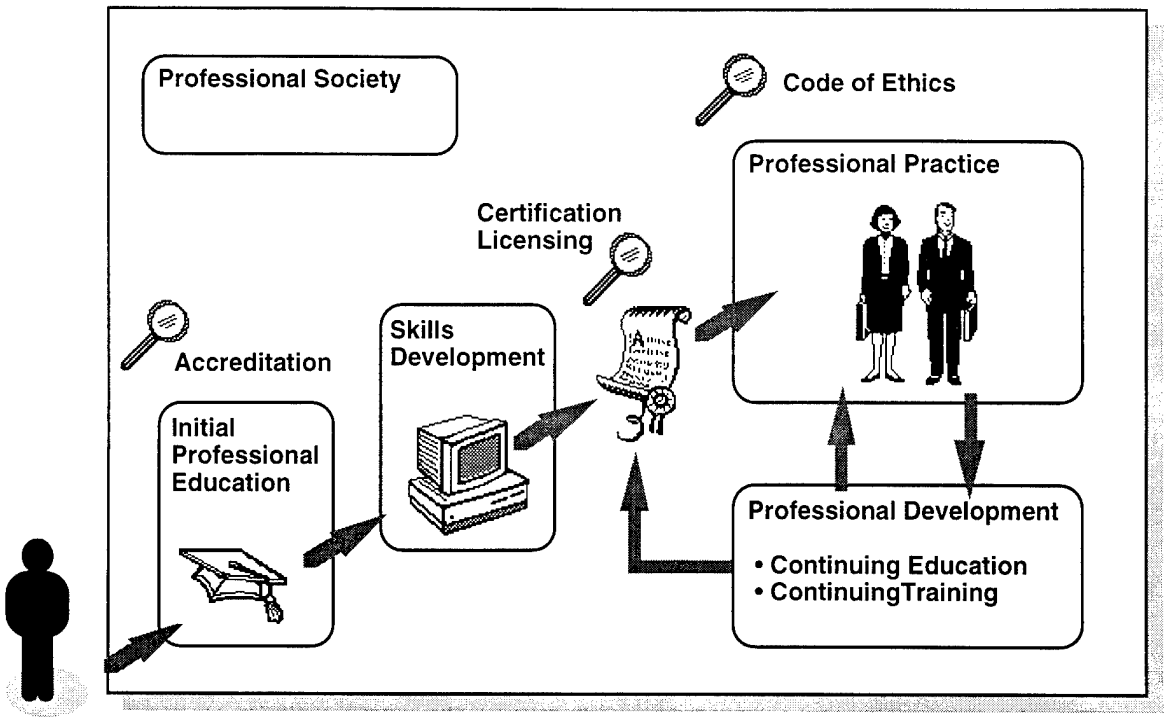

Figure 1.2: Infrastructure-Level Components of a Profession

The interactions among the components of a profession are actually considerably more complex than might be inferred from Figure 1.2. For example, the requirements for professional licensing can have a significant effect on the content of initial professional education. A professional society may manage the certification process or may develop the code of ethics. Certification guidelines can influence the content of professional development. Figure 1.3 shows some of these interactions. Note that the overall effect of these interactions is improved professional practice.

1.3 What Constitutes a Mature Profession?

We have often heard it stated that software engineering is an immature profession. To make sense of this assertion, we need to develop our model further to include the concept of *maturity*. We can approach this in several ways: a global concept of maturity applicable to the global concept of a profession, a concept of maturity for each of the two levels of our model, or concepts of maturity for the individual components that make up a level of the model.

Our investigations have convinced us that it is not productive to attempt a top-down definition of maturity for a profession. The overall concept of a profession is too intangible to permit meaningful assessment or measurement of what we might want to call maturity.

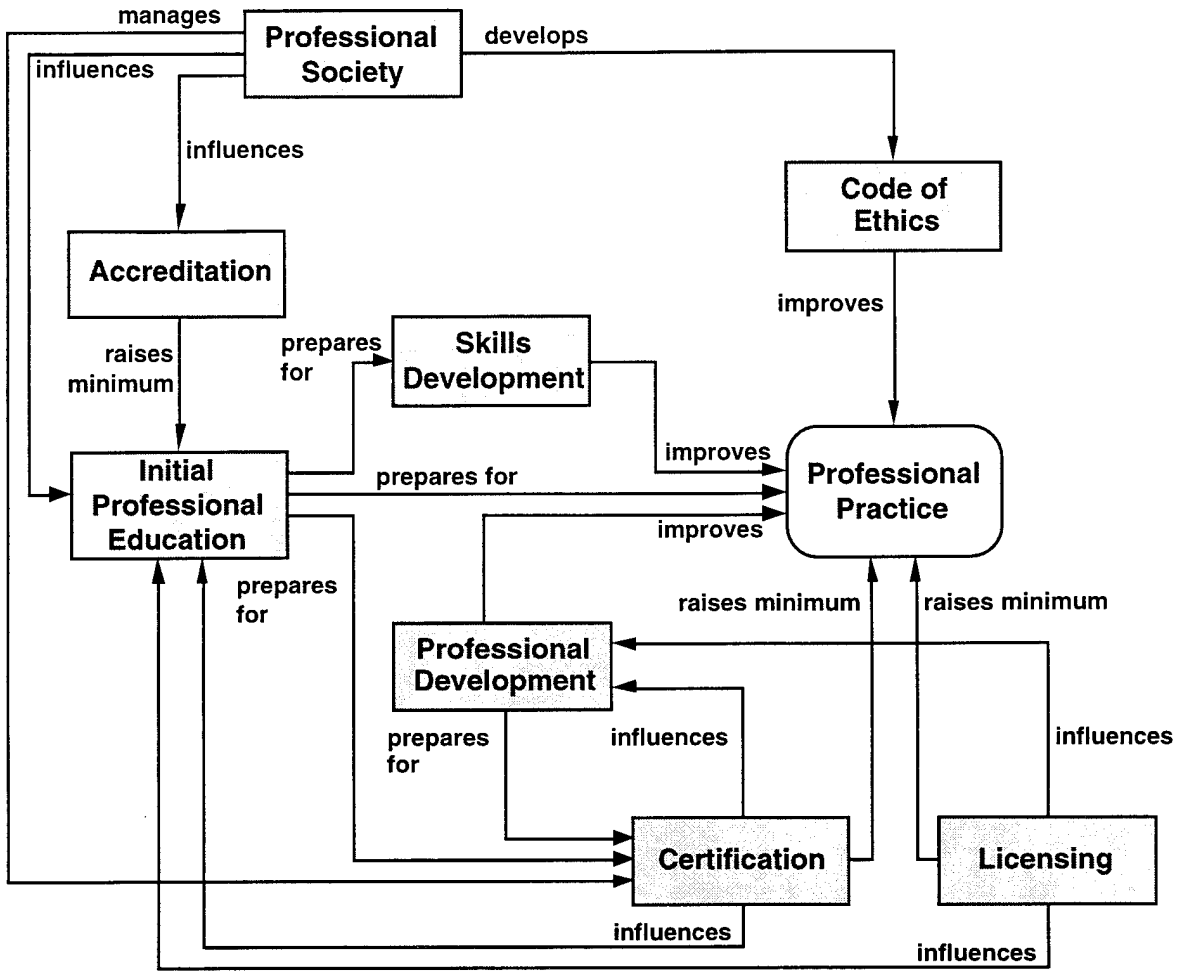

Figure 1.3: Examples of Interactions among Components of a Profession

On the other hand, a bottom-up approach seems feasible. In oversimplified terms, we can try to define maturity for each of the components in our model, and then define the maturity of the profession as a function (such as a weighted average) of the maturities of the components.

We tried this approach using the practitioner level of the model, with little success. Consider the three components at that level: professionals (people), knowledge, and professional practice (activities). What would constitute maturity of each of these components?

The maturity of people can be assessed in the biological sense or in the intellectual sense, but neither assessment is particularly useful in describing the maturity of a profession. The maturity of knowledge seems impossible to characterize; our investigations suggest that the body of knowledge for any given profession continues to evolve over time and that there is no definable point at which it changes from immature to mature. Similarly, professional practice evolves as the body of knowledge changes, so it seems impossible to identify the point at which that practice has become mature.

The bottom-up approach was much more successful when applied at the infrastructure level of the model. At that level, the components are substantially more tangible and identifiable, and we can come closer to recognizing their stages of (im)maturity.

We have chosen to characterize the maturity of the infrastructure-level components of a profession in terms of four developmental or evolutionary stages:

0. Nonexistence	The component does not exist in any form even remotely related to the given profession.
1. Ad Hoc	Some related form of the component exists, but it is not identified with the given profession.
2. Specific	The component exists and is clearly identified with the given profession.
3. Maturing	The component has existed for many years, during which time it has come under the active stewardship of an appropriate body within the profession and is being continually improved.

As an example, let us describe possible stages of the licensing component for a future software engineering profession:

0. Nonexistence	There is no professional license of any kind that in any way mentions electronic computing in any form. This stage existed up to 1960 and probably a little beyond.
1. Ad Hoc	State licensing as a professional engineer required some knowledge of electronic circuits, perhaps including digital electronics, and later some knowledge of basic concepts of computer programming. This stage probably began in the 1960s and continues to today.
2. Specific	State licensing as a professional engineer can be based partly on an examination specifically designed to address software engineering knowledge, as is now the case for several other engineering disciplines (civil, mechanical, electrical, etc.). This stage has not yet been reached in any of the 50 states of the United States.
3. Maturing	State licensing is based on examinations appropriate for software engineers, with the full cooperation and endorsement of organizations such as the National Society of Professional Engineers and the National Council of Examiners for Engineering and Surveying. Licensing requirements are comparable in all the states. Licensing of software engineers is recognized and accepted by the profession as being meaningful in appropriate situations as a way of protecting the public.

With these definitions of the maturity stages of the infrastructure components, we can define a mature profession as one whose components have reached the maturing stage.

The medical profession provides an illustration of the power of this approach to defining maturity. In the 1930s, the eight infrastructure components of the medical profession were already all in the maturing stage, which would cause us to say that the profession was mature at that time. We also note that in that era, the profession did not yet know about penicillin, the structure of DNA, or the genetic basis of many diseases, and they did not have such technologies as heart-lung machines and magnetic resonance imag-

ing. However, because of the mature infrastructure, new knowledge and technologies were adopted by the practitioner community as they appeared—that is the great advantage of having a mature profession.

The medical profession also illustrates our assertion above that it is impossible to define maturity for the body of knowledge of a profession. By today's standards, the knowledge and technologies of the medical profession in the 1930s were something less than "mature." However, by the standards of the 2050s, today's knowledge and technologies will seem less than mature. The body of knowledge will always be evolving, thus making it impossible to identify a point at which it becomes "mature".

In Chapter 3 of this report, we will present our assessment of the current maturity stages for the components of a profession of software engineering and our predictions for how those components might evolve. Before doing that, we need to explore the forms that these components take in professions that are commonly recognized as being mature.

2 Exploring and Validating the Model

We introduced a model of a profession in Chapter 1 with the goal of providing an appropriate structure by which we could describe the future of the software engineering profession. Before attempting to develop that description, we need to *explore the model,* by which we mean examine each of the components of the model in the context of the common professions. It is through this exploration that we will be able to understand the full range of possibilities for each of the components.

An obvious question at this point is this: what occupations are commonly regarded as professions? There are many, but we have chosen to explore the model by looking primarily at medicine (including, as appropriate, nursing, dentistry, and other "healing arts"), law, engineering, and accounting.

This chapter contains nine sections. Each of the first eight explores one of the eight components. The final section presents our conclusions on the validity of the eight-component model for characterizing the infrastructure of a profession and the usefulness of the model for guiding efforts to improve that infrastructure.

2.1 Initial Professional Education

The United States higher education system provides a wide spectrum of educational programs. Toward one end of that spectrum are programs providing what is commonly called *liberal* education; toward the opposite end are programs providing *professional* education.

We could define *professional* education in the broadest sense to be that education that provides the specialized knowledge needed to pursue a particular craft, trade, vocation, or profession. For the purposes of this report, however, we choose a somewhat narrower interpretation, along the lines of the wording in the U. S. Code of Federal Regulations cited in Chapter 1: professional education provides "knowledge of an advanced type in a field of science or learning customarily acquired by a prolonged course of specialized intellectual instruction and study."

Initial professional education for the common professions occurs at two levels, baccalaureate and post-baccalaureate. Examples of professions and the typical entry-level degrees include:

Medicine

physician:	Doctor of Medicine (MD)
dentist:	Doctor of Dental Surgery (DDS)
nurse:	Bachelor of Science in Nursing (BSN)

Law

lawyer:	Doctor of Jurisprudence (JD)

Engineering

civil engineer:	Bachelor of Science in Civil Engineering (BSCE)
mechanical engineer:	Bachelor of Science in Mechanical Engineering (BSME)

Architecture

architect:	Bachelor of Architecture (BArch)
landscape architect:	Bachelor of Landscape Architecture (BLA)

Accounting

accountant:	Bachelor of Science in Accounting

We note that there is a trend toward broader ranges of professionals participating in some professions, resulting in a wider range of kinds of initial professional education. For example, Stanford University offers four different degrees for students interested in the legal profession: Doctor of Jurisprudence, Doctor of Juristic Science, Master of Science in Law, and Master of Jurisprudence. The medical profession has paramedics, nurses, physician's assistants, and many kinds of technicians; none of these requires post-baccalaureate education (in some cases, only a two-year associate's degree is needed). The engineering profession has technicians and technologists who need two- or four-year degrees at the baccalaureate level.

We also note that the level of initial professional education can change. For many years, pharmacists have entered the profession with a Bachelor of Science in Pharmacy degree. In 1992, the American Association of Colleges of Pharmacy approved the Doctor of Pharmacy as the entry-level degree for all of its members. By the turn of the century, only those with the doctoral degree will be eligible to take the licensing examination. Schools of pharmacy are currently revising their curricula, but it is not yet clear what the entrance requirements will be. It is possible that two years of general studies rather than a four-year degree will be sufficient for entry into the doctoral program.

We see, in the engineering profession, the possibility of another shift in the level of initial professional education. During the middle of this century, engineering undergraduate degrees were commonly five-year programs. Over time, various pressures led universities to evolve these into four-year programs. In the last ten years, the rapid growth of technical knowledge has made it increasingly difficult for engineering schools to teach the students what they need to know in only four years, and pressure is building to expand programs to five years again. However, many people believe that instead of a five-year program leading to a bachelor's degree in engineering, students should pursue a five-year program that leads to both a bachelor's degree and a master's degree. The Massachusetts Institute of Technology has begun experimenting with this approach in some of its engineering programs. Several other engineering schools are also trying various forms of master's degrees for their engineering students [Fitzgerald 96]. If this idea is widely accepted, the master's degree may become the entry-level degree for the engineering profession.

2.2 Accreditation of Professional Education Programs

Accreditation is a mechanism to assure the quality of educational programs. Colleges and universities in the United States normally have institutional accreditation from a

regional association, of which there are six:

Middle States Association of Colleges and Schools
New England Association of Schools and Colleges
North Central Association of Colleges and Schools
Northwest Association of Schools and Colleges
Southern Association of Colleges and Schools
Western Association of Schools and Colleges

In addition, there are specialized accreditation bodies that accredit individual programs within a school. The academic and professional communities generally consider accreditation bodies to be legitimate only if those bodies are themselves recognized by the Council on Recognition of Postsecondary Accreditation (CORPA) and by the United States Department of Education.

The professional programs at many colleges and universities are accredited by bodies associated with a particular profession. Examples from the common professions include

Medicine
Accreditation Council for Continuing Medical Education
Accreditation Council for Graduate Medical Education
Accreditation Review Committee on Education for Physician's Assistants
American Federation of Medical Accreditation
Commission on Dental Accreditation of the American Dental Association
Council on Medical Education of the American Medical Association

Law
American Bar Association

Architecture
National Architectural Accrediting Board
American Society of Landscape Architects

Engineering
Accreditation Board for Engineering and Technology (ABET)

There are a few other university-level programs that are sometimes accredited. Programs in computer science can be accredited by the Computing Sciences Accreditation Board (CSAB). Programs in chemistry are often accredited by the American Chemical Society. However, at this time neither computer science nor chemistry is widely regarded as a profession.

2.3 Skills Development

In addition to learning a body of knowledge, persons entering a profession are also expected to develop skill in the application of that knowledge. Skills development takes many forms.

Historically, one of the most common forms of skills development was *apprenticeship*. Prior to the 20th century, apprenticeships were also more common than college degrees as the primary mechanism for learning the body of knowledge of a profession. In engineering, it was not until 1916 that more than 50% of practicing engineers had any kind of college degree.

Today, most professional programs in colleges and universities include skills development in the form of laboratory courses, student projects, design competitions, special summer off-campus programs, or cooperative education (placing students in industry for one or more semesters).

Perhaps the most visible skills development occurs in the medical profession. Physicians are expected to develop a range of skills prior to and early in professional practice. Examples include the use of various instruments (without causing undue discomfort to the patient), performing examinations, taking patient medical histories, and diagnosing illnesses. In some cases, developing these skills begins very early in medical school. For example, at some medical schools, students practice examination skills on each other within the first two weeks of the first year, and they are assisting in examination of actual patients shortly after that. In other cases, physicians will spend years developing the skills, such as the diagnosis skills or surgical skills developed during the residency period. For most of the skills required of physicians, the medical profession has prescribed effective, structured mechanisms for developing them.

Some professions have informal apprenticeships, during which time new practitioners develop a range of skills. In the legal profession, many recent graduates of law schools spend time as law clerks where they develop their skills in legal research and writing. Recent engineering graduates often spend a period of time as an "engineer-in-training" prior to taking a state licensing examination.

2.4 Certification

Certification and licensing are often confused, because they are both intended to be mechanisms to assure the competence of professionals. Somewhat informally, we distinguish them in this way:

Certification is a voluntary process administered by a profession.

Licensing is a mandatory process administered by a governmental authority.

Unfortunately, the popular usage of the two terms is not this cleanly separated. To further complicate the matter, the term *registration* is also sometimes used for similar mechanisms.

Perhaps the most widely known professional certification is in the accounting profession, where a practitioner is commonly referred to as a Certified Public Accountant (CPA). The medical profession has the most extensive certification program. The National Board of Medical Specialties offers certification in more than 20 different areas of medicine, such as surgery, psychiatry, and anesthesiology.

Certification programs are sometimes administered by a professional society. For example, the American Society for Quality Control (ASQC) offers several kinds of certification, including a new program to certify software quality engineers.

Some certification programs are administered by not-for-profit organizations, usually with a board of directors from the profession. An example is the Institute for the Certification of Computing Professionals, Inc. (ICCP), whose board includes representatives from several computing-related professional societies.

In the engineering profession, professional engineers are supported by engineering technicians and technologists. The National Institute for Certification in Engineering Technologies offers certification with one of five designations: Associate Engineering Technician, Engineering Technician, Senior Engineering Technician, Associate Engineering Technologist, and Certified Engineering Technologist. Of course, this does not constitute certification of engineers, but it suggests the breadth of *quasi-professional* positions within a major profession.

There are also certification programs offered by commercial companies, usually related to their own products and services. For example, Novell offers a program leading to designation as a "Certified Network Engineer" for persons who pass an examination on Novell's networking products; Apple Computer offers a program leading to designation as an "Apple Certified Server Engineer". This kind of certification is not usually regarded as *professional* certification.

Certification requirements usually include education and experience. In most cases, a written examination is used to determine the competency of the individual seeking certification.

2.5 Licensing

We have characterized licensing as a mandatory process administered by a governmental authority. In the United States, that authority is almost always at the state level, rather than at the national or local (county, city, township) level. However, for most licensed professions, there are national organizations that advise the states on appropriate licensing requirements and examination content.

The purpose of licensing is the protection of the public. This theme is explicitly stated again and again in the laws of the various states (see Appendix 6). For example, the Minnesota statutes include this statement:

> In order to safeguard life, health, and property, and to promote the public welfare, any person in either public or private capacity practicing, or offering to practice, architecture, professional engineering, land surveying, or landscape architecture, or using the title certified interior designer in this state, either as an individual, a copartner, or as agent of another, shall be licensed or certified as hereinafter provided. [Section 326.02, Subdivision 1]

Perhaps the most widely recognized licensed professions are medicine and law. The licensing requirements in these professions include a substantial amount of education and training, plus passing a rigorous examination. Licensing is an absolute requirement for professional practice in these professions.

Engineering is also a licensed profession. However, the laws of the various states differ somewhat on the kind of work that can only be performed by licensed engineers. Most states exempt engineers in industrial corporations from the licensing requirements (see Appendix 10). For example, section 6747 of the California business and professions code states:

> This chapter, except for those provisions which apply to civil engineers and civil engineering, shall not be applicable to the performance of engineering work by a

manufacturing, mining, public utility, research and development or other industrial corporation or by employees of such corporation, provided such work is in connection with or incidental to the products, systems, or services of such corporation or its affiliates.

As a result of this kind of exemption, most engineers are not licensed. Table 2.1 shows the percentage of engineers in common engineering disciplines who do eventually seek state licenses.

Discipline	Licensed
Civil	44%
Mechanical	23%
Electrical	9%
Chemical	8%
All Engineers	18%

Table 2.1: Percentage of Licensed Engineering Graduates

A discussion of professional licensing is complicated by two facts. First, there are several variations on the licensing concept that go by different names, including *registration* and *certification*. For example, in California, registration is required for psychoanalysts, optometrists, and dispensing opticians. Also in California, certification is required (by the state, not by the profession) for landscape architects, but architects are licensed.

Second, there are several occupations that require state licenses, but that are not usually considered professions. For example, in California, licenses are required for barbers, locksmiths, private investigators, embalmers, automotive lamp and brake adjusters, professional and amateur boxers, custom upholsterers, jockeys and exercise boys in horse or mule racing, and about 50 other occupations (see Appendix 13).

2.6 Professional Development

We use the term *professional development* to mean all the activities intended to improve or maintain the currency of the knowledge and skills of a professional after he or she begins professional practice. It includes everything from the occasional reading of an article in a professional magazine to lengthy continuing education or training[1] required for relicensing or recertification.

[1]We distinguish education and training. *Training* involves the acquisition of specific skills through instruction and practice. The goal of training is to reduce variance from "the one best way" to perform a task. It is usually provided in small pieces that can be immediately used in doing one's work. *Education* inherently has much broader goals than training; it seeks to instill certain qualities in students that will enable them to respond effectively in the future to diverse intellectual challenges. It involves more than the memorization and recall of facts; it also must incorporate students' development of critical thinking abilities and constructive attitudes about themselves, their work, and society.

Because professional development encompasses so many things, it was not possible to find consistent examples across the range of common professions. We did, however, find two patterns.

First, professional development seems most important in professions where there is a rapidly evolving body of technical knowledge on which professional practice is based. Medicine is perhaps the most obvious example—the growth of knowledge about the genetic basis of diseases, new pharmaceuticals, and new diagnostic and treatment technologies places great demands on physicians to stay current.

Second, in many professions, including engineering, professional development tends to focus on small activities with short-term gains for particular projects, rather than on long-term career development. For example, it is more common for professionals to take a short course on a particular tool or technique that will be used in their next job assignment than it is for them to take courses on more fundamental advances in their fields.

We note that there are many factors that might motivate a person to pursue professional development. To some extent, it is the nature of people who think of themselves as professionals to want to stay abreast of advances in their fields. However, we believe that most professional development, especially continuing education, is motivated by either economic or regulatory factors. A better understanding of those factors is helpful to people planning for, designing, or providing professional development services.

The typical economic factor is the assumption that professional development will improve the productivity of practitioners and/or the quality of their products and services, both of which can contribute to increased profit for their employers.

A regulatory factor is exemplified by this excerpt from the statutes of the state of Washington regarding the licensing of physicians:

> ... Every person licensed to practice medicine in this state shall register with the secretary of health annually, and pay an annual renewal registration fee determined by the secretary as provided in RCW 43.70.250. The commission may establish rules governing mandatory continuing education requirements which shall be met by physicians applying for renewal of licenses. The rules shall provide that mandatory continuing education requirements may be met in part by physicians showing evidence of the completion of approved activities relating to professional liability risk management. ... [RCW 18.71.080]

We also note that there are cultural factors that affect professional development. For example, we understand that in France, in professions such as medicine, attaining the appropriate university degree and professional license is all that is thought necessary—it would almost be an insult to suggest that the practicing professional would need additional education or training.

2.7 Code of Ethics

In order to ensure that its practitioners behave in a responsible manner, many professions have adopted a code of ethics (sometimes called a *code of conduct* or *code of practice*). In fact, it is the acceptance of and the commitment to adhere to a code of ethics

that makes many individuals feel that they are indeed part of a community of professionals. A profession takes its responsibility to the public seriously, as indicated by its creation and maintenance of a code of ethics, and by its specification of sanctions or discipline for members who violate the code.

The medical and legal professions have the most extensive and mature codes of ethics (medical ethics began with the oath of Hippocrates dating to about 400 B.C.). The importance of ethics in these professions is obvious, because individuals often must trust their lives to their physicians and lawyers.

To illustrate the range of issues addressed by codes of ethics, Appendices 15 through 24 present several examples of codes (or topic outlines of the codes).

2.8 Professional Society

As a profession develops, voluntary associations of professionals tend to emerge. At first, they may be scholarly societies whose purpose is to promote the exchange of knowledge in support of professional practice. Over time, they may evolve into organizations with a wide range of goals and responsibilities. Scholarly activities may include publishing journals, conducting conferences and symposia, designing model curricula for professional education programs, and publishing text or reference books for professionals. They may also take on various regulatory functions, such as defining certification criteria, managing a certification program, or managing accreditation of professional education programs in universities. They often define codes of ethics and specify disciplinary action for violations of those codes. Some societies will also take on significant political roles, including lobbying legislative bodies and engaging in litigation on matters of concern to the profession.

Most mature professions will have several associated societies. There may be one "senior" society that has mostly political and regulatory roles. Other societies often focus on scholarly activities for a particular branch or specialization within the profession.

In the United States, there are literally thousands of societies associated with the professions and occupations. Two of the largest and best known are the American Medical Association and the American Bar Association, both of which provide the full range of products and services described above. The engineering profession is represented by societies associated with individual engineering disciplines, such as the Institute of Electrical and Electronics Engineers and the American Society of Mechanical Engineers. There is also a broader society, the National Society of Professional Engineers. Computing professionals are represented by the Association for Computing Machinery, the Computer Society of the IEEE, the Data Processing Management Association, and several others.

We note that the percentage of people in a profession who belong to one or more societies could be considered an indicator of the maturity of a profession. We were not able to find definitive numbers for the various professions, but we determined that the percentage is apparently very high for physicians. For the engineering professions, we found that perhaps 10% to 30% of practitioners belonged to a professional society. We note that the combined membership of the ACM and the IEEE Computer Society is

roughly 100,000, while estimates of the number of computer programmers and analysts in the United States range as high as one million.

2.9 Conclusions

In this chapter, we have explored the eight-component model of professional infrastructure by describing the various forms of the components as they exist in several common professions. That exploration has led us to several conclusions.

1. For the common professions, nearly all of the components exist. The medical profession exhibits all eight, and it appears to be the only profession that has mature forms of both certification and licensing. The legal profession exhibits seven—it has licensing but not certification. Architecture, accounting, and engineering also exhibit seven of the components—each has either certification or licensing, but not both.

2. For the common professions, nearly all the components are in the maturing stage. By our definition, this means that each component has existed for many years, during which time it has come under the active stewardship of an appropriate body within the profession and is being continually improved.

3. Professions in which the practitioners are self-employed and offer their professional services directly to the public seem to have somewhat more mature components than the professions in which the practitioners tend to be employed in large organizations.

4. There are many occupations that exhibit a small number of the components, but occupations are not usually regarded as professions. For example, we noted in Section 2.5 that custom upholsterers, amateur boxers, private investigators, and mule racing jockeys require licenses in the state of California, but none of these occupations has lengthy initial professional education in the form of accredited college programs.

5. Because of the wide variation of the forms of various components, the model should be considered primarily descriptive rather than prescriptive.

6. The previous conclusion notwithstanding, the model can probably be used with some confidence to predict in general terms the evolution of the infrastructure components of emerging professions. In particular, the model (especially as it is instantiated in the traditional engineering disciplines) can be used to help forecast the evolution of the software engineering profession. This is the subject of the next chapter.

3 The Software Engineering Profession

In Chapter 2, we examined the eight infrastructure components of a profession, with examples from the common professions. We concluded that the eight-component model offers a reasonable way to characterize the maturity of a profession at the infrastructure level.

Today, the software engineering profession is relatively immature. In fact, many people do not even recognize it as a profession, as suggested by this paragraph of the United States Code of Federal Regulations [29 CFR Sec. 541.302(h)]:

> The question arises whether computer programmers and systems analysts in the data processing field are included in the learned professions. At the present time[2] there is too great a variation in standards and academic requirements to conclude that employees employed in such occupations are a part of a true profession recognized as such by the academic community with universally accepted standards for employment in the field. ...

In the remainder of this chapter, we use the model to characterize the software engineering profession. In each of the eight sections, we first describe one component of the software engineering profession as it exists today, and then we describe how that component might evolve as the profession matures. Each section concludes with suggestions for the next steps that can be taken to increase the maturity of that component.

Overall, we believe that the components of the existing engineering professions are the best predictors of the form of the components for the software engineering profession. This is perhaps not surprising—the name "software engineering" was originally adopted because the nature of the work was so similar to engineering work. We also note that, as in the established engineering professions, most software engineers are employed by companies that build software-intensive systems under contract to specific customers, or build software systems as products for commercial sale. This is in contrast to professions such as medicine and law, where the professionals more often provide direct services to individuals.

3.1 Initial Professional Education

3.1.1 The Current State

The current population of software engineers has anything but a uniform educational background. Practitioners who entered the field prior to about 1970 are almost all people who began programming as part of some other kind of work, and then gradually made it their full time work. More recently, perhaps the majority of people entering the field have degrees in computer science or computer engineering, although many still have other (or no) college degrees.

[2] We could not find the exact date when this paragraph of the code was written, although it appears to have been no later than 1984.

Even among software engineers with a computer science degree, there is considerable variation in preparation. Within the last ten years, most computer science curricula have added a one-semester elective course on software engineering. Such courses present software engineering in a superficial manner, comparable to an attempt to teach all of civil engineering or all of mechanical engineering in a single, one-semester course. Furthermore, being elective courses, not all students take them. Thus the graduates enter the profession with only bits and pieces of knowledge about software engineering.

The main reason for this diversity of educational background among software engineers is that the profession is so new that it has not yet evolved an identifiable form of initial professional education. No United States college or university offers a bachelor's degree in software engineering (BSSE). Approximately 20 universities offer a master's degree in software engineering, but because almost all of those programs specify professional software development experience as an entrance requirement, they cannot be considered *initial* professional education.

A few schools in the United States are taking steps toward providing professional education in software engineering at the undergraduate level [Ford 94]. The Rochester Institute of Technology has designed a BSSE program and expects to receive approval to begin offering it in the fall of 1996. Parks College of St. Louis University offers a Bachelor of Science in Computer Software Systems degree; they intend the program to be a software engineering program, but for internal reasons, they found it impossible to use the word "engineering" in the program title. The Oregon Institute of Technology offers a Bachelor of Science in Software Engineering Technology degree, but an examination of their curriculum shows it to be very similar to a traditional computer science curriculum. It is noteworthy, however, in that it is accredited as an engineering technology program by ABET, thus setting a precedent for ABET accreditation of programs with the phrase "software engineering" in their titles.

Undergraduate programs in software engineering *are* already appearing in other countries. In the United Kingdom, there are at least 13 such programs (in a country with fewer than 100 universities), and in Australia, there are at least three. Appendix 2 lists these schools.

Referring to the evolutionary stages introduced in Section 1.3, we conclude that initial professional education of software engineers is in the ad hoc stage.

3.1.2 Future States

In our exploration of the eight-component model of the infrastructure of a profession (presented in Chapter 2), we noted that all the mature professions we examined had initial professional education (IPE) in the form of a university program in the discipline of the profession. We also noted that initial professional education in the engineering profession takes the form of baccalaureate degrees in the specific engineering discipline. Extrapolating from these facts, it is possible to conclude that initial professional education for a future, mature software engineering profession will be in the form of bachelor's degrees in software engineering. However, we discovered that such a vision is not widely shared in the computing and software communities, nor is it widely shared inside the SEI. Other forms of initial professional education for software engineers are advocated by various constituencies. In this section, we present typical arguments supporting some of them.

Arguments in favor of undergraduate degrees in software engineering predate the development of our model of a mature profession. In fact, the earliest such argument that we have found is from 1969 [Kuo 69]! Proponents of this approach usually base their arguments on their perceived inadequacies of undergraduate computer science degrees in the preparation of students for software engineering careers. They then argue two points: that IPE should be at the undergraduate level and that it should be in programs specifically designed for and thus named "software engineering".

For the first point, they assert that software engineering should and will be accepted as one of the engineering disciplines, and they point out that the other branches of engineering have practitioners who mostly enter the profession with a bachelor's degree in the particular engineering discipline (civil, electrical, mechanical, etc.). They state that they have found no characteristics of software engineering that suggest it is sufficiently different from the other engineering disciplines as to require a different level of initial professional education.

They also point to the recent history of enrollments in the computing disciplines, which suggest that students are unwilling to postpone their careers in order to seek a graduate degree. For example, approximately 25% of students in the sciences go immediately to graduate school after earning their bachelor's degrees; for computer science students, it is only 5%. Also, judging by the number of degrees awarded in the computing disciplines at both the bachelor's and master's levels, probably no more than about 20% of students will *ever* pursue an advanced degree. A software engineering profession that relied on post-baccalaureate programs for initial professional education might have more than 80% of its practitioners without professional education in the discipline.

The arguments in favor of named software engineering degrees are centered on assertions that goals of computer science education and of professional education in software engineering are sufficiently different that it would be impossible to achieve both in a common program. Proponents usually have two bases for their arguments: the different natures of the two disciplines, and the constraints of accreditation guidelines and curriculum recommendations.

On the nature of the disciplines, proponents again express a belief that software engineering is (or soon will be) engineering, and then they cite definitions of science and engineering to show the fundamental differences required to educate their respective practitioners. Fred Brooks described these differences in his characterization, "A scientist builds in order to learn; an engineer learns in order to build." These differences can also be seen in the definitions of the two disciplines. Consider the definition of computing produced by the ACM/IEEE Computer Society Task Force on the Core of Computer Science [Denning 89]:

> The discipline of computing is the systematic study of algorithmic processes that describe and transform information: their theory, analysis, design, efficiency, implementation, and application. The fundamental question underlying all of computing is, "What can be (efficiently) automated?"

Compare that definition to typical definitions of software engineering:

> The systematic approach to the development, operation, maintenance, and retirement of software. [IEEE 83]

> Software engineering is the technological and managerial discipline concerned with systematic production and maintenance of software products that are developed and modified on time and within cost estimates. [Fairley 85]
>
> The disciplined application of engineering, scientific, and mathematical principles, methods, and tools to the economical production of quality software. [Humphrey 89]

The differences between the two disciplines are pervasive and result in quite different approaches to education. The education of a new engineer requires the establishment of an engineering attitude or mind-set, which is engendered by the faculty who provide that education. For that reason, the ABET accreditation guidelines include requirements for faculty, using phrases such as "at least four faculty members educated as engineers or with extensive engineering experience." The guidelines also make clear the desirability that faculty members be licensed professional engineers. It is uncommon for a computer science faculty to meet these requirements.

Regarding the forces that constrain the design of computer science curricula, proponents of separate software engineering programs assert that the recommended curricula of the professional societies and the accreditation requirements of CSAB almost guarantee that significant amounts of software engineering *cannot* be put into the curriculum. By the mid-1980s, most schools had begun offering a one-semester course in software engineering. But these schools also offered one-semester courses in compiler construction, operating systems, computer architecture, analysis of algorithms, database systems, computability, artificial intelligence, numerical analysis, computer networks, automata theory, and a few other significant areas of computer science. Curriculum recommendations from the professional societies continue to stress the need for this breadth of coverage in undergraduate programs. Thus it seems unlikely that universities would be willing to displace enough of these topics from the computer science curriculum to allow meaningful coverage of software engineering—to do so would utterly destroy the computer science curriculum.

On the other hand, another large segment of the software community believes that a computer science curriculum *can* accommodate the needs of software engineers for initial professional education. Several schools have modified their curricula toward this goal; some have added required courses in software engineering, some offer additional elective courses, and some are creating separate tracks or options in software engineering [Ford 94]. An important example of this approach is at Carnegie Mellon University. The school has offered a graduate degree, Master of Software Engineering (MSE), for several years. Beginning in 1996, they plan to offer an undergraduate computer science program that includes as a concentration the entire core curriculum of the MSE program.

Proponents of this approach to IPE for software engineers argue that software engineering is grounded in computer science, much as mechanical engineering is grounded in physics, and thus can grow naturally out of a computer science program. They also suggest that it is much easier to implement in a university, both for procedural reasons (fewer proposals to be made and committee approvals to be secured) and for political reasons (not using the word "engineering" in the program name prevents jurisdictional battles).

Regardless of their positions on software engineering degree names, almost everyone in the software engineering community agrees on two points. First, whatever the form of initial professional education in the university, software engineers will need a range of skills development activities before they can perform as competent, professional software engineers. This topic is considered again in Section 3.2.3.

Second, all agree that the actual set of knowledge, skills, and abilities appropriate to a software engineer entering the profession are not fully understood, and that substantial further work is needed to build this understanding before any specific model of initial professional education can be fully validated.

3.1.3 Next Steps

The segment of the United States academic community that provides professional education is generally responsive to the needs of the professions they support. In particular, schools listen to the practitioners, the industries that employ them, and their professional societies. Thus the most important step in the establishment of initial professional education for software engineers is a clear expression of need from the software community. We believe that the companies who employ software engineers will have the loudest voice and that they need to exercise it.

Some universities are already attempting to educate students for careers as software engineers. A likely scenario for the next ten to twenty years is that, one by one, schools will begin offering much better professional education than is now the case, and that the graduates of these schools will be recognized by potential employers as being much more valuable employees than they are used to hiring directly out of school. Those graduates will get more job offers and command higher salaries. Educators, students, and parents will begin to see the value of professional education in software engineering, and the demand will cause a significant growth in the availability of that education. Catalysts for this evolution include a well articulated demand from industry and the development of professional education guidelines or model curricula by the professional societies.

3.2 Accreditation

3.2.1 The Current State

As mentioned in Section 2.2, there are two accreditation bodies that accredit programs that produce most of today's new software engineers. The Computing Sciences Accreditation Board (CSAB) accredits programs in computer science, and the Accreditation Board for Engineering and Technology (ABET) accredits programs in computer engineering. Within their respective fields, we consider these bodies and their procedures and guidelines to be mature.

A significant problem is on the horizon, however. When the first United States university establishes a bachelor's degree program in software engineering and seeks accreditation, which body will claim jurisdiction?[3] The two bodies have an agreement that programs with the word "engineering" in their titles should be accredited by ABET, while those with the phrase "computer science" in their titles should be accredited by CSAB.

[3]We note that ABET has already accredited, as an engineering technology program, the Bachelor of Science in Software Engineering Technology at the Oregon Institute of Technology.

Nevertheless, because of the close relationship between computer science, many educators believe that CSAB should play an active role in the accreditation of software engineering programs when they emerge.

This potential conflict may be averted in a most reasonable manner. Late in 1994, CSAB and ABET began talks about a possible merger of the two bodies. We believe this merger would be a positive step. In particular, we believe that it would prevent the jurisdictional battle when the first school requests accreditation of a software engineering program, which in turn would allow the people involved to devote their energies to the creation of appropriate accreditation guidelines rather than to political maneuvering.

The development of accreditation guidelines specific to software engineering is important, because we believe that neither the CSAB guidelines for computer science nor the ABET guidelines for computer engineering are appropriate. An example of the basis for this belief comes from a presentation by Boeing's senior manager of corporate compensation at the 1994 ACM SIGCSE Technical Symposium on Computer Science Education.

The speaker noted that Boeing has 112,000 employees, of which 12,000 do software full-time. Boeing is always trying to recruit good software engineers. To facilitate their recruiting, they have studied the curricula of more than 200 computer science programs in United States universities to determine if the graduates are learning enough about software development to be hired by Boeing. In 1993, there were 116 CSAB-accredited programs. Of those, 5 were not reviewed by Boeing, 62 were reviewed and found acceptable, and 49 were reviewed and found unacceptable. In other words, 42% of accredited computer science programs were producing graduates not qualified to work as software engineers at Boeing.

On the other hand, Boeing trusts ABET accreditation of engineering programs. They will only hire graduates of ABET-accredited programs into engineering positions within the company. They do *not* conduct studies of the curricula of ABET-accredited programs in order to determine whether the graduates would be acceptable to Boeing.

We do not take this example as an indication that the CSAB accreditation guidelines are wrong. The guidelines were developed to accredit programs in *computer science* (including programs in liberal arts colleges as well as professional programs in universities), not programs in *software engineering*. Because the two disciplines are different, the accreditation guidelines should be different. Both disciplines are important and we hope both will flourish.

Referring to the evolutionary stages introduced in Section 1.3, we conclude that accreditation of software engineering education is in the ad hoc stage.

3.2.2 Future States

As we stated at the beginning of this chapter, we believe that the mature software engineering profession will have much in common with the other engineering professions. One of these common features will be accreditation of initial professional education by the Accreditation Board for Engineering and Technology (ABET). There is already overwhelming acceptance of ABET accreditation in the industrial community; many large corporations will *only* hire graduates of ABET-accredited programs for engineering positions. We believe that having ABET accreditation of software engineering programs will facilitate and accelerate the acceptance of software engineers as engineers in indus-

try, which will mean that software engineers will be compensated according to engineers' salary scales and will have career advancement opportunities similar to other engineers.

We also believe it to be in the best interest of the software engineering profession for ABET to merge with CSAB, as discussed in Section 3.2.1.

ABET has turned to the professional societies in the various engineering disciplines to develop accreditation guidelines. In some cases, two or more societies have jointly developed guidelines (although one was designated the lead society.) Over the past decade, the IEEE Computer Society and the ACM have collaborated on many issues related to computer science education, including a major effort by the Joint Curriculum Task Force to produce curriculum guidelines for undergraduate programs in computing-related fields. Our vision is that these two societies will jointly work with ABET at the appropriate time to develop the accreditation guidelines for undergraduate software engineering programs in universities.

3.2.3 Next Steps

We believe that, eventually, ABET will accredit software engineering programs in universities. However, ABET will not accredit any program that has not already produced graduates, and currently there are no United States universities with BSSE degree programs. Thus a first step toward establishing accreditation is the creation of a program in at least one university. It is possible that the Rochester Institute of Technology will create the first program in 1996.

Many engineering schools have indicated that they would not even consider offering professional education in software engineering until ABET begins to accredit such programs. Thus the first accreditation will be a significant catalyzing event for professional education in software engineering.

3.3 Skills Development

3.3.1 The Current State

Our definition of profession included the requirement that practitioners develop skill in applying the knowledge learned in their initial professional education. As far as we know, the software engineering profession has not yet identified the skills needed by its practitioners.

We can anticipate several kinds of skills that will ultimately be recognized as important to software engineers. One kind is manual skills, such as touch typing (now commonly called "keyboarding"). Another includes skills in structured behaviors, such as those required of the various participants in software technical reviews. A third is communication skills, which would include such things as interviewing customers to elicit software requirements. A fourth is skill in operating software tools effectively.

Initial professional education provides some opportunities for skills development. Most students learn basic software tools through class programming assignments. Semester-length project courses develop some software engineering skills, as does participation in industry co-op programs. Other skills are developed once a person begins his or her first job as a software engineers.

We note that there are no uniform or profession-wide skills development activities, so we conclude that this component is in the ad hoc stage.

3.3.2 Future States

As described in the previous section, there are many kinds of skills that might be useful to a software engineer, but there is no widespread agreement on which are most important, which are necessary for entry into the profession, and which are acquired at various stages of career development. Thus the first part of our vision for the mature profession is that it *has* achieved a substantial level of agreement on those questions. This would have three major aspects:

1. A rough taxonomy of software engineering skills. For example, we can imagine categories such as manual skills (keyboarding, etc.), general communication skills (making oral presentations, writing coherent prose, etc.), specialized communication skills (interviewing to elicit user requirements, etc.), tool skills (facility with CASE tools, document production tools, etc.), procedural skills (playing the various roles in a software technical inspection, etc.), and programming skills (writing syntactically correct code, debugging, etc.).

2. Descriptions of measurable skill levels in each category. This is the most difficult of the three aspects, but it is necessary in order to define skills development activities for all stages of the career of a software engineer.

3. Identification of the levels of skills that are important upon entry into the profession and at various major stages of or specializations within a person's career. The skills needed at entry would therefore be part of the specification (along with knowledge specifications) of the goals of initial professional education. Software engineers who specialize in various process activities (requirements analysis, design, testing, measurement, etc.) or in particular application domains (real-time systems, information systems, etc.) would be able to plan skills development activities to help them achieve these career goals. Similarly, engineers who will become managers can plan to develop the skills needed in that kind of position.

The second part of our vision for the mature profession is that there are effective skills development activities available when and where needed. As mentioned above, some of these activities will be the responsibilities of the universities providing initial professional education. Others will be provided by employers at appropriate points in a career.

We do not yet feel confident defining a particular form for employer-provided skills development—for example, apprenticeships or the teaching hospital/residency model of the medical profession. We believe this particular issue deserves considerably more study *after* the profession reaches some agreement on the skills that are needed.

3.3.3 Next Steps

As noted in Section 3.2.3, we do not yet have a clear vision of the skills development component for the software engineering profession. It is thus impossible to discuss specific actions to achieve that vision.

A catalyzing event would be research to identify the skills (as distinguished from knowledge) that a software engineer needs. To some extent, this kind of work has been done

by many companies, although such work usually identifies knowledge and skills without carefully distinguishing the two. An important contribution would be for an organization to identify, collect, and analyze existing results in this area, and then to synthesize a clear definition of the needed skills.

3.4 Certification

3.4.1 The Current State

There are several forms of certification of computing or software professionals already in existence. These certification programs are administered in three different ways: by organizations specifically created to do certification, by professional societies, and by commercial companies.

Perhaps the best known of the certification programs is that conducted by the Institute for Certification of Computing Professionals (ICCP), which has offered certification for more than twenty years. It currently offers two designations: Associate Computing Professional (ACP) and Certified Computing Professional (CCP).

The requirements for the ACP designation include scoring 50% or better on two multiple choice examinations, one on core topics in computing and one on the basics of a programming language (Pascal, BASIC, RPG/400, COBOL, C, or C++). Until last year, ICCP also included language examinations in Fortran, RPG II, and Ada. According to the ICCP press release of April 5, 1994, these examinations were discontinued at the end of 1994 "in order to make room in the examination format for emerging technologies." The three languages were chosen because of "lack of participation and also lack of prominence in the industry."

The requirements for the CCP designation include scoring 70% or better on three multiple choice examinations, one on core topics in computing, and two chosen from this list: management, procedural programming, systems development, business information systems, communications, office information systems, systems security, software engineering,[4] and systems programming. Applicants must also have "at least 48 months of full-time (or part-time equivalent) direct experience in computer-based information systems." A bachelor's degree in computer science or information systems can be counted as 24 months of experience.

The most recently created form of certification is offered by the American Society for Quality Control (ASQC). A certified professional is designated as a Software Quality Engineer, which is defined as "a professional who understands the standards and principles of software quality. The Software Quality Engineer understands and analyzes all elements of the software development process."

Certification requirements include

- eight years of professional experience. At least three years must be spent in a decision-making position. A bachelor's degree may be counted as four years of experience, or an advanced degree may be counted as five years of experience.

[4]The outline of the software engineering examination appears in Appendix 4.

- proof of professionalism. This may be membership in an appropriate professional society, holding a professional engineer's license, or statements from two professional colleagues.
- completion of a written examination. The examination outline is presented in Appendix 5; it is taken from draft 5.8 (October 1992) of the ASQC certification brochure.

In addition, successful applicants agree to abide by the ASQC code of ethics.

As mentioned in Section 2.4, there are commercial companies such as Learning Tree International, Novell, Apple Computer, and Microsoft that offer a form of certification related to software development. The program offered by Learning Tree is among the most extensive, offering certification in 14 areas:

- PC Service and Support
- Local Area Networks
- Wide Area Networks
- Internetworking
- Open Systems
- Client/Server Systems
- Oracle7 Database Administration
- Oracle7 Application Development
- NetWare 3.x
- NetWare 4.x
- UNIX Programming
- UNIX Systems
- C and C++ Programming
- Software Development

These commercial forms of certification are not generally regarded as professional certification in the sense intended by our model of the professional infrastructure. None of them addresses the broad range of knowledge and skills needed by software engineers.

We conclude that the certification component of the software engineering profession is currently in the ad hoc stage.

3.4.2 Future States

In the previous section, we noted that there are already some certification programs related to software engineering. ASQC certification is too new to have made an impact on the practitioner community. We believe that, despite its age, ICCP certification has not had much impact either. We have not had the resources to investigate and substantiate this claim, so we can only speculate on the reasons why it might be true. First, we have the impression that ICCP certification was created for the data processing community, and therefore it is perhaps better known there than in the software engineering community. Second, the topics addressed in the certification examinations seem not to include much of what is important to software engineers in domains such as embedded real-time systems. Third, and perhaps most important, there does not seem to be any tangible benefit associated with achieving certification.

This third point will become very important in the evolution of a mature certification component of the software engineering profession. Simply stated, software engineers

will need a reason for going to the trouble of becoming certified. Unfortunately, like many problems that can be simply stated, the solution is not so simple.

One commonly suggested way of motivating certification (of software engineers or other professionals) is that employers make it a condition of employment. However, this might be difficult to implement because of federal equal employment opportunity laws, which place considerable burdens on employers to show the fairness of selection procedures such as written tests. See Appendix 6 for a discussion of this point in the context of ICCP certification.

Our vision for the future of certification for the software engineering profession is based on one significant belief: certification is more desirable than licensing. There will be growing demands for safety and security in software-intensive systems. If the profession does not provide effective mechanisms such as certification to assure that its practitioners are doing everything possible to promote safety and security, then government will try to do it with licensing.

We believe that certification will evolve out of professional society activities, such as the current effort by the ACM and IEEE Computer Society to "establish the software engineering profession." It will begin with a general certification that spans all of the fundamental knowledge and skills of an entry-level software engineer. Over time, we expect specialty certifications to emerge, including both specialization by domain (embedded systems, information systems, etc.) and by type of skill (requirements specification, design, testing, etc.).

We expect that certification will not become a condition of employment, but it will be seen as a highly desirable credential by software engineers, especially those entering the profession after certification begins. Eventually, specialty certification will be seen as valuable by more experienced software engineers as they follow particular career paths. Software organizations will use certification as one of the criteria for choosing people to hire, to assign to particular projects, and to promote.

3.4.3 Next Steps

The first step toward establishment of a widely accepted certification program for the software engineering profession will be the emergence of a credible champion for the idea. The most likely candidates seem to be the ACM and the IEEE Computer Society. The long-term plans of their joint effort to establish the software engineering profession include the formation of a task force to examine certification issues.

The champion will need to build support for certification in the software community. At the present time, there seems to be almost universal opposition to certification among practitioners. This is understandable, partly for the psychological reason that it poses a threat to their perceptions of their competence, and partly because there is not yet any evidence that certification will solve any existing problem in the software engineering profession.

Certification, by our definition (see Section 2.4), is voluntary. As discussed in Section 3.4.2 and Appendix 6, it is unlikely to soon become a condition of employment. We believe peer pressure will be a significant motivation for seeking certification, as will an individual's pride in achievement and recognition.

One scenario for introducing certification is self-assessment. Through this mechanism, software engineers can become familiar with the kinds of examinations that might be used for certification, recognize weaknesses in their own backgrounds without anyone sitting in judgment, and use the results to help plan their own professional development. We believe that as this practice becomes widespread, the software engineers doing it will emerge as leaders and more valuable employees, and they will be so recognized by their employers.

On the other hand, as we noted in Section 3.4.1, voluntary ICCP certification has existed for more than 20 years, but it has not had widespread impact on software professionals. It would be valuable to conduct a study of the validity of that assertion and, if it is true, to determine the reasons why. The results of such a study could be a significant influence on the design of a certification program for software engineers.

A second important step toward the establishment of a certification program is identifying the knowledge and skills of software engineers that would be required for certification. We note that such work might be done in conjunction with similar work related to other infrastructure components. For example, suppose the profession decides it wants to certify software engineers at the entry level—when they first begin professional work. In a mature profession, we would expect that the knowledge and skills required for certification would be closely related to the knowledge and skills that are specified as the goals of initial professional education.

3.5 Licensing

3.5.1 The Current State

At the present time, there is no form of licensing specifically for software engineers. We have heard many unsubstantiated reports of attempts in recent years by state legislatures to adopt some form of licensing regulations for software engineers. We believe that pressure for this kind of licensing will increase and that many more states will consider such legislation in the next five to ten years.

We did find one documented example of such an effort. In 1990, the legislature of the state of New Jersey considered a bill (reproduced in its entirety in Appendix 12) that would have established a licensing requirement for software engineers. As with other engineering disciplines, the purpose was to protect the public, as stated in Section 2 of the original wording of the bill:

> The Legislature finds and declares that the public interest requires the regulation of the practice of software engineering and the establishment of clear licensure standards for software engineers, and that the welfare of the citizens of this State will be protected by identifying to the public those individuals who are qualified and legally authorized to practice software engineering.

The bill defined software engineering as "the process of creating software systems and applies to techniques that reduce software cost and complexity while increasing reliability and modifiability, which includes, but is not limited to, the elements of requirements engineering, design specification, implementation testing and validation, operation and maintenance and software management."

The bill passed in the New Jersey general assembly in the spring of 1991, but it was never adopted by the state senate. Apparently, the bill received little public scrutiny prior to passage in the lower house, but quite a bit afterward. Most of the software community did not support the bill, and some thought it irrelevant in that no one would bother to become licensed. Many also argued that the licensure would not increase the quality of software, both because the state of the art of software engineering was not sufficiently advanced and because the kinds of knowledge that could be tested in a written examination did not necessarily correspond to the knowledge needed to produce high quality software.

An interesting sidelight to this story is the reaction of the engineering community in New Jersey, as evidenced by the actions of the New Jersey section of the American Society of Mechanical Engineers (ASME). This group sent a formal statement (see Appendix 13) to the legislature that did not comment on the merits of the bill with respect to achieving its stated purpose, but rather objected to the use of the word "engineering". The ASME statement recommended that the term "software designer" be substituted throughout the bill, and the legislature adopted this recommendation.

With this change, one of the requirements for licensure was to provide evidence that the candidate has "[g]raduated from a program in software designing which has been approved for the education and training of software designers by an accrediting agency recognized by the Council on Post-Secondary Accreditation and the United States Department of Education." Given the wide acceptance and use of the term "software engineering", it seems unlikely that universities will initiate degree programs in "software designing" or that ABET would accredit them. Thus the bill, even if it became law, would probably have been moot.

This incident emphasizes the large number of organizations (in this case, a state legislature, the engineering community, the software community, the academic community, and accreditation agencies) that will necessarily be involved, and have to agree with each other, if licensing of software engineers is ever to happen.

Another example of the confusing situation regarding state licensing and software engineering comes from the state of California. Early in 1995, the California State Board of Registration for Professional Engineers and Land Surveyors made some changes in the regulations that would seem to begin regulating the development of some kinds of software. For example, the new regulations would include "associated software and/or firmware" in the definition of engineering design products that must be built by licensed engineers. See Appendix 10 for an excerpt of the new regulations.

Software engineers can be licensed under existing engineering licensing statutes, but there is little incentive to do so. Most states exempt from licensing requirements those engineers whose engineering work is done in companies producing manufactured products (see Appendix 10 for examples of such exemptions in the statutes of several states). Furthermore, the time a person would spend learning the material currently covered on state licensing examinations would be time *not* spent learning software engineering; this would be disadvantageous to a successful professional career as a software engineer.

Thus we conclude that the licensing component of the software engineering profession is in the ad hoc stage.

3.5.2 Future States

In the previous section, we stated that we believe certification is preferable to licensing as a way of assuring a minimum competency level of software engineers. However, as we noted in Section 2.5, there is substantial precedent for licensing software engineers in the licensing by the states of engineers in the traditional engineering disciplines. We also noted that some states have already attempted to adopt licensing requirements for software engineers. The pressure to license software engineers will grow with each publicized software failure, especially when there is loss of life or substantial loss of property.

If we accept the assertion that licensing is inevitable, then we believe it is important that the profession be prepared to advise the state legislatures about the nature of software and the appropriate contents of a licensing examination. Fortunately, there is significant common ground in efforts to define certification guidelines and efforts to define licensing guidelines, so doing work on the former will also prepare for the latter.

Several organizations have been active in the formulation of model statutes and examinations for the licensing of engineers. Among the most important of these are the National Society of Professional Engineers and the National Council of Examiners for Engineering and Surveying. Our vision is that these organizations, in collaboration with the ACM and IEEE Computer Society, will support the development of meaningful licensing guidelines and examinations for software engineers.

We also note that we believe that future licensing statutes will be patterned after those for the traditional engineering disciplines. For that reason, we can expect exemptions for software engineers in industrial corporations (as described in Section 2.5). Because of this exemption, we might expect that less than 10% of software engineers would ever seek, or need to seek, licensure (as is the case for electrical and mechanical engineers).

3.5.3 Next Steps

Licensing is the responsibility of governmental authorities, usually state government. As noted in Section 3.5.2, societies including the National Society of Professional Engineers, the National Council of Examiners for Engineering and Surveying, the ACM, and the IEEE Computer Society are likely to be involved in advising state legislatures as licensing laws are developed. We do not have any information that would permit us to predict how soon licensing of software engineers will occur or how widespread it will be.

3.6 Professional Development

3.6.1 The Current State

Of all the components of the professional infrastructure for software engineering, professional development may be the most mature: we conclude it is in the specific stage. Both continuing education and training directly related to software engineering are widely available. This includes individual courses and graduate programs in universities, professional development courses and conferences offered by professional societies, courses provided by training vendors, and the in-house programs in the larger software companies.

One problem remains. Because of the relative youth of the software engineering profession, there have not yet emerged any standards or guidelines for professional development. Software engineers tend to take a course or engage in other professional development activities mostly when their employers perceive a need and are willing to pay the costs. As the profession matures, we would expect there to be better defined career paths and professional development goals for software engineers.

3.6.2 Future States

Professional development is perhaps the most nebulous of the eight infrastructure components, in that it includes many kinds of activities, each of which can take many forms. As we noted in Section 2.6, the variability of professional development across the common professions leaves us without a single clear vision of what it would be in a mature software engineering profession. However, we can describe a general vision.

- Software organizations will recognize the value of and invest in continuing professional development of software engineers. Professional development activities will include continuing education as well as training, and professional development will be considered a strategic investment in a career as well as a tactical investment in a specific project.
- There will be nationally recognized and accepted guidelines for career paths and for the knowledge and skills that are needed by software engineers doing particular tasks or building particular kinds of systems. The profession, through its professional societies, will actively maintain and improve those guidelines.
- The existence of guidelines will facilitate the maturation of a secondary industry that provides continuing education and training courses for software engineers.

3.6.3 Next Steps

In the previous section, we acknowledged that we do not have a clear vision for professional development, primarily because it involves many different kinds of activities that can be structured in many different ways. We do believe that the employers of software engineers will be the leaders in the evolution of these activities.

There are several kinds of actions that would accelerate and enhance the evolution of professional development. First, the emergence of either certification or licensing of software engineers would provide specific goals at which professional development activities could be aimed. Second, the collection and publication of quantitative data on the return on investment for various forms of professional development will motivate many organizations. Such data is likely to be more accessible as organizations involved in large-scale process improvement activities begin measuring more aspects of their processes. Third, the development of career path definitions and job descriptions by the profession will give many organizations goals for professional development that they now lack. Fourth, the creation of self-assessment instruments, such as those published over the last 15 years by the ACM, will help individual software engineers identify where professional development is needed.

Once the software engineering profession begins to develop clear goals for professional development, backed up by data on the economics, there will be roles and opportunities for the universities and the continuing education and training vendors to provide appropriate courses.

3.7 Code of Ethics

3.7.1 The Current State

There are several existing codes of ethics related to computing and software development, although none yet specifically addresses the software engineering profession. Perhaps the best known of these are those promulgated by the ACM (see Appendix 21) and by the IEEE Computer Society (see Appendix 22).

Acceptance of a code of ethics is sometimes a requirement of professional certification or licensing. An example is the code of ethics of the ICCP, adherence to which is a requirement for certification as a Certified Computing Professional. Also, in some states, the statutes addressing the licensure of engineers include a code of ethics to be followed by professional engineers (see Appendix 20 for an example). Because none of these codes of ethics specifically addresses software engineering, we conclude that this component of the professional infrastructure is in the ad hoc state. However, this situation is likely to change soon. Since 1993, a task force chartered by the IEEE Computer Society and the ACM has been working to draft a code of ethics for the software engineering profession. The task force has made considerable progress: they have written and circulated for comment many drafts of the code, and they have made presentations and many major conferences related to computing or software. We expect their work to be published and endorsed by the societies in the next couple of years.

3.7.2 Future States

As we noted in the previous section, the professional societies are likely to endorse a code of ethics for software engineers relatively soon. Our vision for the mature profession is that this code of ethics is taught during initial professional education, accepted and followed by practitioners, and actively maintained by the societies.

3.7.3 Next Steps

The next steps are already being taken by the professional societies, and we await their results.

3.8 Professional Society

3.8.1 The Current State

In the United States, there is no professional society specifically aligned with the software engineering profession, so we could conclude that this component of the professional infrastructure is in the ad hoc stage. However, both the Association for Computing Machinery (ACM) and the Computer Society of the Institute for Electrical and Electronics Engineers (IEEE) provide a wide range of products and services for software engineers. Furthermore, the two societies are currently cooperating on a long-term effort to "establish the software engineering profession." For these reasons, we would probably be justified in concluding that this component is effectively in the specific stage of our model.

We note that there is at least one organization that seems to be a professional society for software engineers: the Software Engineers Association. One of its members reported to the SEI:

Software Engineers Association of Japan was established in December 1985 to provide a "place for software engineers or researchers, who are working in different environments such as software houses, computer manufacturers, computing service bureaus, universities, and research laboratories, to exchange their technical experience or knowledge freely beyond the barriers of existing social organizations."

SEA's major activities are: publication of monthly newsletter (Seamail), operating local chapters and special interest groups, holding seminars/workshops/ symposia, and cooperation with related academic/professional societies in and outside Japan.

At present [October 1995], SEA has about 700 individual members and about 40 institutional members. 7 local chapters (in Osaka, Yokohama, Nagano, Nagoya, Kyushu, Sendai, and Hiroshima) and several number of special interest groups (Environment, Education, Network, Process, etc.) are in operation.

Finally, we also note that there are many other professional organizations related to computing, such as the Data Processing Management Association.

3.8.2 Future States

As we noted in Section 3.8.1, the ACM and the IEEE Computer Society are already providing a range of products and services specifically for software engineers. We believe it is likely that they will continue to do so, and thus the software engineering profession is unlikely to need another professional society. Our vision is that the ACM and the IEEE Computer Society will continue to address the needs of the profession.

3.8.3 Next Steps

The next steps are already being taken by the professional societies. It is the responsibility of all professional software engineers to contribute to the efforts of the societies to support the profession.

3.9 Summary

In Section 1.3, we introduced these evolutionary stages of the infrastructure components of a profession:

0. Nonexistence	The component does not exist in any form even remotely related to the given profession.
1. Ad Hoc	Some related form of the component exists, but it is not identified with the given profession.
2. Specific	The component exists and is clearly identified with the given profession.
3. Maturing	The component has existed for many years, during which time it has come under the active stewardship of an appropriate body within the profession and is being continually improved.

Our brief look at the current state of the infrastructure of the software engineering profession shows it to be quite immature. Only the professional development component and the professional society component have begun moving past the ad hoc stage.

We can summarize our vision for the evolution of the software engineering profession as shown in Table 3.1.

Component	Ad Hoc	Specific	Maturing
Initial Professional Education	Bachelor's degrees in computer science, engineering, mathematics, etc., are the common preparation for entry into the profession	A recognized form of initial professional education in software engineering exists, but there is no standard curriculum	Curricula reflect the best practice; nationally accepted model curricula exist; model curricula are regularly reviewed and revised
Accreditation of Education	Accreditation based on computer science or engineering criteria	Accreditation based on software engineering criteria; ABET and CSAB merged	Accreditation guidelines are regularly reviewed and revised
Skills Development	Some student project work in schools; some co-op programs; some company training programs for new hires	Guidelines have emerged for the skills needed by a software engineer for entry into the profession	Skills development mechanisms are in place and widely used (such as apprenticeships or engineer-in-training programs); skills for distinct specializations are recognized and developed
Certification	ICCP, ASQC certification; commercial certification related to software packages and technologies	Certification as a software engineer; nationally recognized certification standards	Certification in specialty areas within software engineering; nationally recognized specialty certification standards
Licensing	State licensing as a professional engineer under existing statutes	Some state licensing examinations address software engineering skills specifically	Licensing is based on appropriate examinations; NSPE and NCEE collaboration; recognized as protecting the public in appropriate situations
Professional Development:	Individuals pursue professional development as they determine the need	Professional development guidelines (curricula, expenditures per year, etc.) have emerged	Recognized generalist and specialist career paths for software engineers; nationally recognized education and training guidelines and curricula
Code of Ethics	Codes of ethics of ACM, IEEE, ASQC, ICCP; engineer licensing statutes	Code of ethics specifically for software engineers	Code widely respected and adopted; the profession has mechanisms to discipline violators
Professional Society	ACM, IEEE Computer Society, others	Society explicitly states that it represents software engineering	Society has appropriate range of products and services for software engineers

Table 3.1: Evolution of Components of the Software Engineering Profession[5]

[5]Acronyms used in this table are:

ABET Accreditation Board for Engineering and Technology
ACM Association for Computing Machinery
ASQC American Society for Quality Control
CSAB Computing Sciences Accreditation Board
ICCP Institute for the Certification of Computing Professionals
IEEE Institute of Electrical and Electronics Engineers
NCEE National Council of Engineering Examiners
NSPE National Society of Professional Engineers

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Appendix 1 Master's Programs in Software Engineering in United States Universities

Master of Science in Software Engineering
- Andrews University
- Colorado Technical College
- DePaul University
- Drexel University
- Monmouth University
- National Technological University
- National University
- Southern Methodist University
- University of Houston, Clear Lake
- University of Missouri-Kansas City
- University of Pittsburgh
- University of Scranton
- University of St. Thomas

Master of Software Engineering
- Carnegie Mellon University
- Embry-Riddle Aeronautical University
- Kansas State University
- Seattle University
- Texas Christian University

Master of Engineering in Software Engineering
- University of Colorado

Master of Science in a software-related discipline
- Air Force Institute of Technology (Software Systems Management)
- George Mason University (Software Systems Engineering)
- Rochester Institute of Technology (Software Development and Management)
- University of Detroit Mercy (Software Management)

Master of <discipline> in a software-related discipline
- Miami University (Systems Analysis)
- University of St. Thomas (Software Design and Development)

Master of Engineering in a software-related discipline
- University of Colorado at Colorado Springs (Software Systems Engineering)

Appendix 2 Undergraduate Software Engineering Programs in the United Kingdom and Australia

United Kingdom

University of Birmingham
BSc (Honours) in Computer Science/Software Engineering

Coventry University
BSc (Honours) Software Engineering

University of Glamorgan
BSc (Honours) Software Engineering

University of East London
BSc (Honours) Software Engineering

University of Greenwich
BSc (Honours) Computing Science (Software Engineering)

Manchester Metropolitan University
BSc (Honours) Software Engineering

University of Newcastle upon Tyne
BSc (Honours) Software Engineering

University of Paisley
BSc (Honours) Software Engineering

Sheffield Hallam University
BSc (Honours) Computing (Software Engineering)

University of Sheffield
BEng (Honours) Software Engineering

Staffordshire University
BSc (Honours) Software Engineering

University of Teesside
BSc (Honours) Software Engineering

University of Wolverhampton
BSc (Honours) Software Engineering

Australia

University of Melbourne
BEng in Software Engineering

Royal Melbourne Institute of Technology
BSc in Software Engineering

Swinburne University of Technology
BSc in Software Engineering

Appendix 3 Outline of ICCP Software Engineering Examination

1. Computer System Engineering
   - 1.1 Computer-Based Systems
   - 1.2 Computer-System Life Cycle Modeling
   - 1.3 Hardware Considerations
   - 1.4 Software Considerations
   - 1.5 Human Considerations
   - 1.6 Data Base Considerations
   - 1.7 System Analysis
   - 1.8 The System Specification
2. Software Project Planning
   - 2.1 Project Planning Objectives
   - 2.2 Software Scope
   - 2.3 Resources
   - 2.4 Metrics for Software Productivity and Quality
   - 2.5 Software Project Estimation
   - 2.6 Decomposition Techniques
   - 2.7 Empirical Estimation Models
   - 2.8 Automated Estimation Tools
   - 2.9 Software Project Scheduling
   - 2.10 Software Acquisition
   - 2.11 Organizational Planning
   - 2.12 The Software Project Plan
3. Software Requirements
   - 3.1 Analysis Principles
   - 3.2 Object-Oriented Analysis
   - 3.3 Software Prototyping
   - 3.4 Specification
   - 3.5 Requirements Analysis Methodologies
   - 3.6 Data Flow-Oriented Analysis Methods
   - 3.7 Data Structure-Oriented Methods
   - 3.8 Data Structured Systems Development
   - 3.9 Jackson System Development
   - 3.10 Automated Tools for Requirements Analysis
4. Software Design
   - 4.1 The Design Process
   - 4.2 Design Fundamentals
   - 4.3 Effective Modular Design
   - 4.4 Data Design
   - 4.5 Architectural Design
   - 4.6 Procedural Design
   - 4.7 Design Documentation
5. Data Flow-Oriented Design
   - 5.1 Design and Information Flow
   - 5.2 Design Process Considerations
   - 5.3 Design Heuristics
   - 5.4 Design Postprocessing
   - 5.5 Design Optimization
6. Data Structure-Oriented Design
   - 6.1 Design Process Considerations
   - 6.2 Design Heuristics
   - 6.3 Logical Construction of Programs and Systems
   - 6.4 Data Structured Systems Development
7. Object-Oriented Design
   - 7.1 Origins of Object-Oriented Design
   - 7.2 Object-Oriented Design Concepts
   - 7.3 Object-Oriented Design Methods
8. Real-Time Design
   - 8.1 Real-Time Systems
   - 8.2 Analysis of Real-Time Systems
   - 8.3 Software Design Methods
9. Programming Languages and Coding
   - 9.1 The Translation Process
   - 9.2 Programming Language Characteristics
   - 9.3 Programming Language Fundamentals
   - 9.4 Language Classes
   - 9.5 Coding Style
   - 9.6 Efficiency
10. Software Quality Assurance
    - 10.1 Software Quality
    - 10.2 Software Reviews
    - 10.3 Formal Technical Reviews
    - 10.4 Software Quality Metrics
    - 10.5 Software Reliability
    - 10.6 Software Quality Assurance Approach
11. Software Testing Techniques
    - 11.1 Software Testing Fundamentals
    - 11.2 White Box Testing

11.3 Basis Path Testing
11.4 Loop Testing
11.5 Black Box Testing
11.6 Proof of Correctness
11.7 Automated Testing Tools
11.8 Strategic Approach to Software Testing
11.9 Unit Testing
11.10 Integration Testing
11.12 System Testing
11.13 Debugging

12. Software Maintenance and Configuration Management
12.1 Maintenance Characteristics
12.2 Maintainability
12.3 Maintenance Tasks
12.4 Maintenance Side Effects
12.5 Software Configuration Management

Appendix 4 Outline of ASQC Certification Examination

1. Software Quality Management
   - 1.1 Software Total Quality Management
   - 1.2 Software Quality Planning
   - 1.3 Participation
   - 1.4 The Software Quality Function
   - 1.5 Quality Information Systems
   - 1.6 Quality Management Tools
   - 1.7 Quality Education and Training
   - 1.8 Professionalism
2. Software Engineering
   - 2.1 Basic Concepts
   - 2.2 Software Engineering Techniques
   - 2.3 Software Engineering Life Cycle
3. Project Management
   - 3.1 Planning and Control
   - 3.2 Managing People
4. Appraisal
   - 4.1 Software Inspections
   - 4.2 Testing
   - 4.3 Verification and Validation
   - 4.4 Assessments, Audits, and Reviews
5. Issues
   - 5.1 Controls
   - 5.2 Data Integrity
   - 5.3 Disaster Planning
   - 5.4 Liability
   - 5.5 Maintainability
   - 5.6 Reliability
   - 5.7 Risk Management
   - 5.8 Safety
   - 5.9 Security
6. Analytical Methods
   - 6.1 Metrics and Measurement
   - 6.2 Probability and Statistics
   - 6.3 Statistical Process Control
7. Quality Systems
   - 7.1 Software Corrective Action
   - 7.2 Software Configuration Management
   - 7.3 Software Standards and Procedures
   - 7.4 Improvement and Innovation
   - 7.5 Software Quality Function Deployment
   - 7.6 Procurement

Appendix 5 Certification as a Condition of Employment

One possible motivation for software engineers to seek professional certification is for employers to make it a condition of employment. To understand why this approach is not as easy as it sounds, consider the following excerpt from a letter from an unnamed person in a corporate personnel office, as published in the December 1991 issue of the AICCP Newsletter, an informal publication of the Association of the ICCP. It describes potential problems with using certification based on a written test (such as used by the ICCP) as a condition of employment.

> There are detailed regulations published by the federal government which control an employer's use of selection procedures. The details of the regulations are quite complex, but the concept behind them is rather simple. If an employer uses a selection procedure which has an adverse effect on designated population subgroups, then the employer must have substantial evidence that the procedure meets a business necessity. In the case of paper and pencil tests, adverse effect will normally be assumed unless the employer has evidence to the contrary since the results of most tests do differ among population subgroups. Virtually all tests used in education and employment show differences among population subgroups. It is possible that the ICCP exams might not behave in this manner, but I doubt that the ICCP even keeps the kind of data relevant to making a determination that pass percentages are not significantly different across all relevant population subgroups.
>
> I am not saying that using a test which has adverse effect is discriminatory. Rather, what such a test does is place a rather severe burden on the employer to show that the test is a valid measure of the skills required for the job. The essence of a business necessity defense in the case of a paper and pencil test is evidence that the test measures skills which are relevant to the specific job in question. This can be done in one of two ways. An employer can offer statistical evidence, usually correlations between test scores and measures of actual job performance which show that higher scores are linked to higher levels of performance. The other approach is to show that the content of the exam covers skills which are essential to the job in question. This is a lot more complex than it may seem. It requires a detailed analysis of the tasks required in the job and of the skills required to perform those tasks. Then each of those tasks must be linked to the questions in the test which are intended to assess those skills. Establishing links between a specific employer's jobs and content of the ICCP exams is likely to be very difficult since the ICCP exams were not written with our particular job descriptions in mind. It is quite possible that some of the ICCP exam questions may be relevant to our jobs, but we have no way of knowing which questions we can use and which we can't.

Appendix 6 Excerpts from Engineering Licensing Statutes—Purpose of Licensing

The engineering licensing statutes of most states explain the purposes of the statute. Below are several examples.

California: "In order to safeguard life, health, property, and public welfare, no person shall practice civil, electrical, or mechanical engineering unless appropriately registered or specifically exempted from registration under this chapter, and only persons registered under this chapter shall be entitled to take and use the titles 'consulting engineer,' 'professional engineer,' or 'registered engineer,' or any combination of those titles, and according to registration with the board the engineering branch titles specified in Section 6732, or the authority titles specified in Section 6763, or 'engineer-in-training.'" [Business and Professions Code, Section 6704]

Colorado: "In order to safeguard life, health, and property and to promote the public welfare, the practice of engineering is declared to be subject to regulation in the public interest. It shall be deemed that the right to engage in the practice of engineering is a privilege granted by the state through the state board of registration for professional engineers and professional land surveyors, created in section 12-25-106; that the profession involves personal skill and presupposes a period of intensive preparation, internship, due examination, and admission; and that a professional engineer's license is solely such professional engineer's own and is nontransferable."

Minnesota: "In order to safeguard life, health, and property, and to promote the public welfare, any person in either public or private capacity practicing, or offering to practice, architecture, professional engineering, land surveying, or landscape architecture, or using the title certified interior designer in this state, either as an individual, a copartner, or as agent of another, shall be licensed or certified as hereinafter provided." [Section 326.02, Subdivision 1]

Pennsylvania: "In order to safeguard life, health or property and to promote the general welfare, it is unlawful for a person to practice or to offer to practice engineering in this Commonwealth, unless he is licensed and registered under the laws of this Commonwealth as a professional engineer, or for any person to practice or to offer to practice land surveying, unless he is licensed and registered under the laws of this Commonwealth as a professional land surveyor." [Section 3.(a)]

Washington: "In order to safeguard life, health, and property, and to promote the public welfare, any person in either public or private capacity practicing or offering to practice engineering or land surveying, shall hereafter be required to submit evidence that he is qualified so to practice and shall be registered as hereinafter provided; and it shall be unlawful for any person to practice or to offer to practice in this state, engineering or land surveying, as defined in the provisions of this chapter, or to use in connection with his name or otherwise assume, use,

or advertise any title or description tending to convey the impression that he is a professional engineer or a land surveyor, unless such a person has been duly registered under the provisions of this chapter." [RCW 18.43.010]

The substantial similarities among these excerpts, especially in their opening words, suggest some collaboration. In the case of routine legislation, the states are often influenced by national organizations who propose model laws, based on their expertise in a particular area. In this case the organization is the National Council of Examiners for Engineering and Surveying, which works to promote uniform standards of registration and to coordinate interstate registration of engineers.

Appendix 7 Excerpts from Engineering Licensing Statutes—Definitions

The excerpts of statutes quoted in Appendix 6 refer to "professional engineers" and to "practicing or offering to practice engineering". It is useful to look at how these ideas are defined in the statutes. Below are several examples.

California: "'Professional engineer,' within the meaning and intent of this act, refers to a person engaged in the professional practice of rendering service or creative work requiring education, training and experience in engineering sciences and the application of special knowledge of the mathematical, physical and engineering sciences in such professional or creative work as consultation, investigation, evaluation, planning or design of public or private utilities, structures, machines, processes, circuits, buildings, equipment or projects, and supervision of construction for the purpose of securing compliance with specifications and design for any such work." [§6701]

Colorado: "'Practice of engineering' means the performance for others of any professional service or creative work requiring engineering education, training, and experience and the application of special knowledge of the mathematical and engineering sciences to such professional services or creative work, including consultation, investigation, evaluation, planning, design, surveying, and the observation of construction to evaluate compliance with plans and specifications in connection with the utilization of the forces, energies, and materials of nature in the development, production, and functioning of engineering processes, apparatus, machines, equipment, facilities, structures, buildings, works, or utilities, or any combination or aggregations thereof, employed in or devoted to public or private enterprise or uses." [§12-25-102(10)]

Indiana: ""Practice of engineering" means any service or creative work that the adequate performance of requires engineering education, training, and experience in the application of special knowledge of the mathematical, physical, and engineering sciences to services or creative work that includes the following:

(1) Consultation.

(2) Investigation.

(3) Evaluation.

(4) Planning, including planning the use of land and water.

(5) The design of or the supervision of the design of engineering works and systems.

(6) Engineering surveys and studies or the supervision of engineering surveys and studies, including all surveying activities required to support the sound conception, planning, design, construction, maintenance, and operation of engineered projects, but not including the surveying of real property for the establishment of land boundaries, subdivisions, rights-of-way, easements,

and the dependent or independent surveys or resurveys of the public land survey system.

(7) Evaluation of construction for the purpose of assuring compliance with specifications, plans, and designs, in connection with any public or private utilities, structures, buildings, machines, equipment, processes, work systems, or projects.

The term "practice of engineering" does not include the work ordinarily performed by persons who operate or maintain machinery or equipment." [IC 25-31-1-2 Sec. 2. (d)]

Minnesota: "Practice of professional engineering. Any person shall be deemed to be practicing professional engineering within the meaning of sections 326.02 to 326.15 who holds out as being able to perform or who does perform any technical professional service, such as planning, design or observation of construction for the purpose of assuring compliance with specifications and design, in connection with any public or private structures, buildings, utilities, machines, equipment, processes, works, or projects wherein the public welfare or the safeguarding of life, health, or property is concerned or involved, when such professional service requires the application of the principles of mathematics and the physical and applied engineering sciences, acquired by education or training, and by experience." [326.02 Subd. 3]

New York: "Definition of practice of engineering. The practice of the profession of engineering is defined as performing professional service such as consultation, investigation, evaluation, planning, design or supervision of construction or operation in connection with any utilities, structures, buildings, machines, equipment, processes, works, or projects wherein the safeguarding of life, health and property is concerned, when such service or work requires the application of engineering principles and data." [§7201]

Pennsylvania: "'Practice of Engineering' shall mean the application of the mathematical and physical sciences for the design of public or private buildings, structures, machines, equipment, processes, works or engineering systems, and the consultation, investigation, evaluation, engineering surveys, planning and inspection in connection therewith, the performance of the foregoing acts and services being prohibited to persons who are not licensed under this act as professional engineers unless exempt under other provisions of this act." [§2.(a)(1)]

"A person shall be construed to practice or offer to practice engineering or land surveying who practices any branch of the profession of engineering or land surveying, or who, by verbal claim, sign, advertisement, letterhead, card, or in any other way represents himself to be an engineer or land surveyor, or through the use of some other title implies that he is an engineer or land surveyor or that he is registered under this act; or who holds himself out as able to perform, or who does perform any engineering service or work or any other service designated by the practitioner or recognized as engineering or land surveying." [§3.(b)]

Washington: "The term 'practice of engineering' within the meaning and intent of this chapter shall mean any professional service or creative work requiring engineering education, training, and experience and the application of special

knowledge of the mathematical, physical, and engineering sciences to such professional services or creative work as consultation, investigation, evaluation, planning, design and supervision of construction for the purpose of assuring compliance with specifications and design, in connection with any public or private utilities, structures, buildings, machines, equipment, processes, works, or projects.

"A person shall be construed to practice or offer to practice engineering, within the meaning and intent of this chapter, who practices any branch of the profession of engineering; or who, by verbal claim, sign, advertisement, letterhead, card, or in any other way represents himself or herself to be a professional engineer, or through the use of some other title implies that he or she is a professional engineer; or who holds himself or herself out as able to perform, or who does perform, any engineering service or work or any other professional service designated by the practitioner or recognized by educational authorities as engineering."

West Virginia: "'Practice of engineering' means any service or creative work, the adequate performance of which requires engineering education, training and experience in the application of special knowledge of the mathematical, physical and engineering sciences to such services or creative work as consultation, investigation, evaluation, planning and design of engineering works and systems; planning the use of land and water; teaching of advanced engineering subjects, engineering surveys and studies; and the review of construction for the purpose of assuring compliance with drawings and specifications any of which embraces such services or work, either public or private, in connection with any utilities, structures, buildings, machines, equipment, processes, work systems, projects and industrial or consumer products or equipment of a mechanical, electrical, hydraulic, pneumatic or thermal nature, insofar as they involve safeguarding life, health or property, and including such other professional services as may be necessary to the planning, progress and completion of any engineering services. Engineering surveys include all survey activities required to support the sound conception, planning, design, construction, maintenance and operation of engineered projects." [§30-13-3.(3)]

We note that the phrase "teaching of advanced engineering subjects" in the West Virginia statute has caused considerable discussion at West Virginia University regarding the credentials of faculty members. Some have argued that if software engineering is to be considered an engineering subject, then it can only be taught by licensed professional engineers. The implication is that computer science professors should not teach that subject.

Appendix 8 Excerpts from Engineering Licensing Statutes—Licensing Requirements

Licensing requirements generally include a certain number of years of engineering work experience under the supervision of a licensed professional engineer and the passing of one or more written examinations. Having a college degree in engineering is not a requirement, but it can be substituted for some of the work experience.

In most states, the process of gaining a license involves two steps. The first involves passing a written examination, after which the candidate is designated an "engineer-in-training." Because this first examination covers fundamental engineering science and mathematics, many candidates take it during their final year in college or immediately after graduation. Subsequently, after completing a number of years of work experience, they take a second examination that focuses on their particular branch of engineering.

As an example of specific requirements, here are the applicable sections of the California business and professions code:

> 6750. An application for registration as a professional engineer or certification as an engineer-in-training shall be made to the board on the prescribed form, with all statements made therein under oath, and shall be accompanied by the application fee prescribed by this chapter. An application for registration as a professional engineer shall specify, additionally, the branch of engineering in which the applicant desires registration.
>
> 6751. (a) The applicant for certification as an engineer-in-training shall comply with all of the following:
>
> (1) Not have committed acts or crimes constituting grounds for denial of registration under Section 480.
>
> (2) Successfully pass the first division of the examination. The applicant shall be eligible to sit for the first division of the examination after satisfactory completion of three years or more of college or university education in a board-approved engineering curriculum or after completion of three years or more of board-approved experience.
>
> The board need not verify the applicant's eligibility other than to require the applicant to sign a statement of eligibility on the application form.
>
> (b) The applicant for registration as a professional engineer shall comply with all of the following:
>
> (1) Not have committed acts or crimes constituting grounds for denial of registration under Section 480.
>
> (2) Furnish evidence of six years or more of qualifying experience in engineering work satisfactory to the board evidencing that the applicant is competent to practice the character of engineering in the branch for which he or she is

applying for registration, and successfully pass the second division of the examination.

(3) The applicant for the second division of the examination shall successfully pass the first division examination or shall be exempt therefrom.

6751.2. The board may consider the professional experience and education acquired by applicants outside the United States which in the opinion of the board is equivalent to the minimum requirements of the board established by regulation for professional experience and education in this state.

6751.5. The board shall by rule establish the criteria to be used for approving curricula of schools of engineering.

6752. An applicant for registration as a civil engineer must have gained his experience under the direction of a civil engineer legally qualified to practice.

6753. With respect to applicants for registration as professional engineers, the board:

(a) Shall give credit as qualifying experience of four years, for graduation with an engineering degree from a college or university the curriculum of which has been approved by the board.

(b) May at its discretion give credit as qualifying experience up to a maximum of two years, for graduation with an engineering degree from a nonapproved engineering curriculum or graduation with an engineering technology degree in an approved engineering technology curriculum.

(c) May at its discretion give credit as qualifying experience of up to one-half year, for each year of successfully completed postsecondary study in an engineering curriculum up to a maximum of four years credit. A year of study shall be at least 32 semester units or 48 quarter units.

(d) May at its discretion give credit as qualifying experience not in excess of one year, for a postgraduate degree in a school of engineering with a board approved postgraduate curriculum.

(e) May at its discretion give credit as qualifying experience for engineering teaching, not in excess of one year, if of a character satisfactory to the board.

The sum of qualifying experience credit for subdivision (a) to (e), inclusive, shall not exceed five years.

The licensing requirements in the state of Indiana are these:

The following under either subdivision (1) or (2) shall be considered as minimum evidence that the applicant is qualified for registration as a professional engineer:

(1) All of the following:

(A) Graduation in an approved engineering curriculum of four (4) years or more.

(B) A specific record of four (4) years or more of progressive experience on engineering projects of sufficient quality acquired subsequent to graduation, which experience indicates that the applicant is qualified to be placed in responsible charge of engineering work requiring the exercise of judgment in the application of engineering sciences to the sound solution of engineering problems.

(C) The successful passing of an examination as provided for in section 14 of this chapter.

(2) All of the following:

(A) A specific record of eight (8) years or more of engineering education and experience in engineering work, which indicates that the applicant has acquired knowledge and skill and practical experience in engineering work approximating that required for registration as a professional engineer under subdivision (1).

(B) The successful passing of an examination as provided for in section 14 of this chapter. [IC 25-31-1-12 Sec. 12. (a)]

The licensing examination is described in the Indiana statutes as follows:

(a) The examination required of all applicants for registration as a professional engineer shall be a written examination which shall be divided into the following two (2) parts, each of eight (8) hours duration:

(1) Engineering fundamentals.

(2) Principles and practice of engineering. The board may adopt rules under IC 4-22-2 establishing additional examination requirements.

(b) The engineering fundamentals portion of the examination shall be designed to test the applicant's knowledge of mathematics and the physical and engineering sciences. The standards of proficiency required shall approximate that attained by graduation in an approved four (4) year engineering curriculum.

(c) The principles and practice of engineering portion of the examination shall be designed primarily to test the applicant's understanding of, and judgment and ability to apply correctly, the principles of:

(1) mathematics;

(2) the physical sciences;

(3) the engineering sciences; and

(4) engineering design analysis and synthesis;

to the practice of professional engineering. A part of the examination may be designed to test the applicant's knowledge and understanding of the ethical, economic and legal principles relating to the practices of professional engineering. [IC 25-31-1-14 Sec. 14.]

The state of New York prescribes these requirement for licensure:

Sec. 7206. Requirements for a license as a professional engineer.

1. To qualify for a license as a professional engineer an applicant shall fulfill the following requirements:

(1) Application: file an application with the department;

(2) Education: have received an education, including a bachelor's or higher degree based on a program in engineering, in accordance with the commissioner's regulations;

(3) Experience: have at least four years in work satisfactory to the board, provided that the board may accept study beyond the bachelor's degree in partial fulfillment of this requirement;

(4) Examination: pass an examination satisfactory to the board and in accordance with the commissioner's regulations;

(5) Age: be at least twenty-one years of age;

(6) Citizenship or immigration status: be a United States citizen or an alien lawfully admitted for permanent residence in the United States;

(7) Character: be of good moral character as determined by the department; and

(8) Fees: pay a fee of two hundred twenty dollars to the department for admission to a department conducted examination and for an initial license, a fee of one hundred fifteen dollars for each reexamination, a fee of one hundred thirty-five dollars for an initial license for persons not requiring admission to a department conducted examination, and a fee of two hundred ten dollars for each triennial registration period.

2. In lieu of the degree and experience requirements specified in subparagraphs (2) and (3) of subdivision one of this section, twelve years of practical experience in work satisfactory to the board may be accepted, provided that each full year of college study in engineering satisfactory to the department may at the discretion of the board be accepted in lieu of two years of the required twelve years of experience.

3. For an identification card as an "intern engineer", an applicant shall fulfill the requirements of subdivision one of this section, except those in subparagraphs (3) and (5), provided that admission to the examination may be given when the applicant is within twenty credits of the completion of the requirements for the bachelor's or higher degree as prescribed in subparagraph (2) of subdivision one, or has completed the practical experience requirement of subdivision two of this section. The fee for examination and identification card as an "intern engineer" shall be seventy dollars and the fee for each reexamination shall be seventy dollars.

4. On recommendation of the board, the department may waive specific requirements, except as to age, character, education and citizenship, in the case of applicants who are possessed of established and recognized standing in the engineering profession and who have practiced lawfully for more than fifteen years.

The Texas statute explicitly mentions different branches of engineering in its engineering licensing requirements.

> §131.101 Engineering Examinations Required for Registration as a Professional Engineer
>
> (a) The written examinations required under the Texas Engineering Practice Act (the Act), §12(a)(1) and (2), will consist of an eight-hour fundamentals of engineering examination and an eight-hour principles and practice of engineering examination. Normally, these examinations will be offered twice each year, once in the first six months (April) and once in the second six months (October) of each calendar year. Written examinations will be held in Austin or places designated by the board.
>
> ...
>
> (g) Applicants must either pass or be exempt from the fundamentals of engineering examination in order to be eligible to take the principles and practice of engineering examination.
>
> ...
>
> (4) There are two groups of the principles and practice examination offered. Group I examinations are offered both in the spring and the fall and include examinations in the following branches of engineering: chemical, civil, (civil, sanitary, structural), electrical, mechanical, and the special structural examinations I and II. Group II examinations are offered only in the fall and include examination in the following branches of engineering: aeronautical/aerospace, agricultural, control systems, fire protection, industrial, manufacturing, metallurgical, mining/mineral, nuclear, and petroleum.
>
> §131.133 Certificates of Registration
>
> (a) The certificate of registration issued by the board in compliance with the provisions of the Act and board rules shall be uniform in all cases. Registration is as professional engineer. Although the Act makes no specific designation as to the branches of engineering practice for which certificates of registration will be issued, the records of the board will indicate the branch considered dominant in accordance with §131.81(7) of this title (relating to Experience Evaluation).
>
> (b) Applications for registration will be accepted only for the branches of engineering for which there is an available principles and practice examination from the National Council of Examiners for Engineering and Surveying (NCEES), and the board records annotated with the corresponding alphabetical code as follows:
>
> (1) (A) aeronautical/aerospace;
> (2) (F) agricultural;
> (3) (K) chemical;
> (4) (C) civil;
> (5) (X) control systems;
> (6) (E) electrical;
> (7) (V) environmental;
> (8) (H) fire protection;
> (9) (L) industrial;

(10) (M) mechanical;
(11) (I) mining/mineral;
(12) (J) metallurgical;
(13) (U) manufacturing;
(14) (N) nuclear;
(15) (P) petroleum;
(16) (S) sanitary;
(17) (B) structural.

(c) The board previously recognized certain other branches of engineering practice for which there are presently no NCEES examinations, but board records were annotated with the corresponding alphabetical code as follows:
(1) (R) biomedical;
(2) (Q) engineering sciences;
(3) (G) geological;
(4) (O) ocean;
(5) (T) textile;
(6) (D) ceramic.

(d) A licensee of the board may represent himself as any kind of an engineer based on the enumerations in subsections (b) and (c) of this section, or based on an educational degree, specialty certification by a private or governmental organization, or other specialized training or experience in a unique field of applied engineering. However, public representations of an engineering specialty shall not be false, misleading, or deceptive in violation of the Act or board rules of practice and procedure.

Appendix 9 Excerpts from Engineering Licensing Statutes—Exemptions

Although the licensing statutes seem to state unequivocally that a person who wants to perform engineering work must be licensed, there are exceptions. Many states, under certain conditions, exempt employees of companies from the licensing requirements. Here is a typical example, from the California business and professions code:

> "6747. This chapter, except for those provisions which apply to civil engineers and civil engineering, shall not be applicable to the performance of engineering work by a manufacturing, mining, public utility, research and development or other industrial corporation or by employees of such corporation, provided such work is in connection with or incidental to the products, systems, or services of such corporation or its affiliates."

The state of Colorado provides exemptions for employees of corporations and for people supervised by a licensed engineer:

> 12-25-103. (1) This part shall not be construed to affect any of the following: ... (c) Partnerships, professional associations, joint stock companies, limited liability companies, or corporations, or the employees of any such organizations, who perform engineering services for themselves or their affiliates; (d) Individuals who perform engineering services under the responsible charge of a registrant; ...

Similarly, the Indiana statute exempts individuals from the licensing requirements in two cases—the work is supervised by a licensed engineer, or the work is related to manufactured products:

> "IC 25-31-1-20 Sec. 20. (a) An employee or a subordinate of any person who holds a certificate of registration under the provisions of this chapter is exempt from the provisions of this chapter if the practice of the employee or subordinate does not include responsible charge of design or supervision.
>
> "(b) This chapter does not require registration for the purpose of practicing engineering by an individual or a business: ...
>
> "(2) for the performance of engineering which relates solely to the design or fabrication of manufactured products; or ..."

Similar exemptions are in the statutes of the state of Washington:

> RCW 18.43.130 Excepted services—Fees. This chapter shall not be construed to prevent or affect: ...
>
> (4) The work of an employee or a subordinate of a person holding a certificate of registration under this chapter, or an employee of a person practicing lawfully under provisions of this section: PROVIDED, That such work does not include final design or decisions and is done under the direct responsibility, checking,

and supervision of a person holding a certificate of registration under this chapter or a person practicing lawfully under the provisions of this section; or

(5) The work of a person rendering engineering or land surveying services to a corporation, as an employee of such corporation, when such services are rendered in carrying on the general business of the corporation and such general business does not consist, either wholly or in part, of the rendering of engineering services to the general public: PROVIDED, That such corporation employs at least one person holding a certificate of registration under this chapter or practicing lawfully under the provisions of this chapter; or ...

The state of New York also has exemptions for employees of corporations. Paragraph j seems to address specifically the distinction between having "engineer" as a job title and being an engineer.

Sec. 7208. Exempt persons. This article shall not be construed to affect or prevent the following, provided that no title, sign, card or device shall be used in such manner as to tend to convey the impression that the person rendering such service is a professional engineer or a land surveyor licensed in this state or is practicing engineering or land surveying: ...

j. The practice of engineering or land surveying or having the title "engineer" or "surveyor" solely as an officer or an employee of a corporation engaged in interstate commerce;

k. The practice of engineering by a manufacturing corporation or by employees of such corporation, or use of the title "engineer" by such employees, in connection with or incidental to goods produced by, or sold by, or nonengineering services rendered by, such corporation or its manufacturing affiliates; ...

Appendix 10 Excerpts from California Business and Profession Code

Recent changes to the California statutes related to the licensing of engineers for the first time specifically mention the production of software.

> Section 6730. In order to safeguard life, health, property and public welfare, any person, either in a public or private capacity, except as in this chapter specifically excepted, who practices, or offers to practice, civil engineering, electrical engineering or mechanical engineering, in any of its branches in this state, including any person employed by the State of California, or any city, county, or city and county, who practices engineering, shall submit evidence that he is qualified to practice, and shall be registered accordingly as a civil engineer, electrical engineer or mechanical engineer by the board.
>
> Section 6717. (k) "Electrical Engineer" is a professional engineer as defined in Section 6701 of the code who holds a valid registration as an electrical engineer as defined in Section 6702.1 of the code. ...
>
> (l) "Electrical engineering" is that branch of professional engineering which involves the use of engineering judgement, the application of engineering principles, engineering analysis, the review of engineering work, and/or the assumption of responsible charge of design or development of electrical devices, electrical equipment, electrical systems, or electrical processes (hereafter collectively termed electrical engineering design products) whose function depends primarily on electrical, electronic, magnetic, or electromagnetic effects and/or phenomena. Electrical engineering design products should comply with applicable codes and recognized standards, where such codes and standards have been established in order to safeguard life, health, property and public welfare, and include but are not limited to such design products in the following areas:
>
> 1) Electrical power generation, transmission, conversion, distribution and utilization, including associated software and/or firmware.
>
> 2) ...
>
> 3) Communication and broadcast networks, systems, and equipment, including telecommunications transmission and switching equipment and facilities, and associated software and/or firmware.
>
> 4) Electrical systems for feedback, stability, amplification and filtering applications, including associated software and/or firmware.
>
> The above definition of electrical engineering does not include the development or production of commercial software, although the development of software for electrical engineering design products may constitute qualifying experience for electrical engineering registration, if all of the other criteria of Section 426.70 are satisfied. For the purpose of the above definition of electrical engineering, the engineer in responsible charge of the design of development of an electrical engi-

neering design product which contains software components is deemed to be responsible for the entire project, including the software components thereof.

Appendix 11 New Jersey Software Designers' Licensing Bill

[State of New Jersey; Assembly Bill 4414; second reprint]

AN ACT providing for the licensure of software designers, amending P.L.1971, c.60, P.L.1974, c.46 and P.L.1978, c.73, and supplementing Title 45 of the Revised Statutes.

BE IT ENACTED by the Senate and General Assembly of the State of New Jersey:

1. (New section) This act shall be known and may be cited as the "Software Designers' Licensing Act."

2. (New section) The Legislature finds and declares that the public interest requires the regulation of the practice of software designing and the establishment of clear licensure standards for software designers, and that the welfare of the citizens of this State will be protected by identifying to the public those individuals who are qualified and legally authorized to practice software designing.

3. (New section) As used in this act:

"Board" means the State Board of Software Designers established pursuant to section 4 of this act.

"Licensed software designer" means any person who practices software designing and who represents himself to the public by title or by description of services under any title incorporating such terms as "software engineer," "software designer," "chartered engineer," or "CEng" or any similar title or description of services, who is duly licensed pursuant to this act.

"Software designing" means the process of creating software systems and applies to techniques that reduce software cost and complexity while increasing reliability and modifiability, which includes, but is not limited to, the elements of requirements designing, design specification, implementation testing and validation, operation and maintenance and software management.

4. (New section) There is created within the Division of Consumer Affairs in the Department of Law and Public Safety the State Board of Software Designers. The board shall consist of nine members who are residents of this State who shall be appointed by the Governor. Six members shall be licensed software designers who have been actively engaged in software designing for at least five years immediately preceding their appointment, except that the members initially appointed shall be licensed pursuant to this act with 18 months of appointment. Of the remaining members, two shall be public members, and one shall be a member of the executive branch, all of whom shall be appointed pursuant to section 2 of P.L.1971, c.60 (C.45:1-2.2).

5. (New section) Each member of the board, except the members first appointed, shall serve for a term of five years and shall hold office until the appointment and qualification of his successor. The initial appointment to the board shall be: two members for

terms of two years, two members for terms of three years, two members for terms of four years, and three members for terms of five years. Vacancies shall be filled for the unexpired term only. No member may be appointed for more than two consecutive terms.

6. (New section) Members of the board shall be compensated and reimbursed for expenses and provided with office and meeting facilities pursuant to section 2 of P.L.1977, c.258 (C.45:1-2.5).

7. (New section) The board shall annually elect from among its members a chair, vice-chair and a secretary. The board shall meet twice per year and may hold additional meetings as necessary to discharge its duties.

8. (New section) The board shall:

a. Review the qualifications of applicants for licensure;

b. Insure the proper conduct and standards of examinations;

c. Issue and renew licenses to software designers pursuant to this act;

d. Refuse to admit examination, refuse to issue, or suspend revoke or fail to renew the license of a software designer pursuant to the provisions of P.L.1978, c.73 (C.45:1-14 et seq.);

e. Maintain a record of every software designer licensed in this State, their places of business, places of residence and the data and number of their license;

f. Establish fees pursuant to P.L.1974, c.46 (C.45:1-3.1 et seq.);

g. Adopt and promulgate rules and regulations pursuant to the "Administrative Procedure Act," P.L.1968, c.410 (C.52:14B-1 et seq.) necessary to effectuate the purposes of this act.

9. (New section) No person shall practice, or present himself as able to practice, software designing unless he possesses a valid license as a software designer in accordance with the provisions of this act.

10. (New section) The provisions of this act shall not be construed to prevent the following provided that no word, letter, abbreviation, insignia, sign, card or device is used to convey the impression that the person rendering the service is a licensed software designer:

a. Any person licensed to practice in this State under any other law from engaging in the practice for which he is licensed;

b. Any person employed as a software designer by the federal government, if the person provides software designing services solely under the direction or control of his federal employer, or

c. Any person pursuing a course of study leading to a degree or certificate in software designing at an accredited or approved educational program if the person is designated by a title which clearly indicates status as a student or trainee.

11. (New section) To be eligible for licensure as a software designer, an applicant shall submit to the board satisfactory evidence that he has:

a. (1) Graduated from a program in software designing which has been approved for the education and training of software designers by an accrediting agency recognized by the Council on Post-Secondary Accreditation and the United States Department of Education; or

(2) Work experience in a current or previous position of employment utilizing the theory and procedures of software designing for a sufficient period of time as determined by the board; and

b. Successfully completed a written examination administered by the board pursuant to section 14 of this act to determine his competence to practice software designing.

12. (New section) An applicant for licensure who is a graduate of a foreign school of software designing shall furnish evidence satisfactory to the board that he has:

a. Completed a course of study in software designing which is substantially equivalent to that provided in an accredited program described in subsection a. of section 11 of this act; and

b. Successfully completed a written examination administered by the board pursuant to section 14 of this act.

13. (New section) A fee shall accompany each application for licensure. Licenses shall expire biennially on January 31 and may be renewed upon submission of a renewal application provided by the board and payment of a fee. If the renewal fee is not paid by that date, the license shall automatically expire, but may be renewed within two years of its expiration date upon payment to the board of a sum determined by it for each year or part thereof during which the license was expired and an additional restoration fee. If a license has not been renewed within two years of expiration, the license shall only be renewed by complying with the provisions of section 16 of this act or successfully completing the examination administered pursuant to section 14 of this act.

14. (New section) The written examination required in section 11, 12 or 13 of this act shall test the applicant's knowledge of software designing theory and procedures and any other subjects the board may deem useful to test the applicant's fitness to practice software designing. Examination shall be held within the State at least once every six months at a time and place to be determined by the board. The board shall give adequate written notice of the examination to applicants for licensure and examination.

If an applicant fails the examination twice, the applicant may take a third examination not less than one year nor more than three years from the date of the applicant's initial examination. Additional examinations shall be in accordance with standards set by the board.

15. (New section) The board shall issue a license to each applicant for licensure as a software designer who qualifies pursuant to the provisions of this act and any rules and regulations promulgated by the board.

16. (New section) Upon payment to the board of a fee and the submission of a written application on forms provided by it, the board shall issue without examination a license

to a software designer who holds a valid license issued by another state or possession of the United States or the District of Columbia which has standards for licensure substantially equivalent to those of this State.

17. (New section) Upon payment to the board of a fee and the submission of a written application on forms provided by it, the board shall issue a temporary license to a person who has applied for licensure pursuant to this act and who, in the judgment of the board, is eligible for examination. A temporary license shall be available to an applicant upon initial application for examination. A person holding a temporary license may practice software designing only under the direct supervision of a licensed software designer. A temporary license shall expire automatically upon failure of the licensure examination but may be renewed for an additional six-month period, until the date of the next examination at which time it shall automatically expire and be surrendered to the board.

18. Section 1 of P.L.1971, c.60 (C.45:1-2.1) is amended to read as follows:

1. The provisions of this act shall apply to the following boards and commissions: the New Jersey State Board of Accountancy, the New Jersey State Board of Architects, the New Jersey State Board of Cosmetology and Hairstyling, the Board of Examiners of Electrical Contractors, the New Jersey State Board of Dentistry, the State Board of Mortuary Science of New Jersey, the State Board of Professional Engineers and Land Surveyors, the State Board of Marriage Counselor Examiners, the State Board of Medical Examiners, the New Jersey Board of Nursing, the New Jersey State Board of Optometrists, the State Board of Examiners of Ophthalmic Dispensers and Ophthalmic Technicians, the Board of Pharmacy, the State Board of Professional Planners, the State Board of Psychological Examiners, the State Board of Examiners of Master Plumbers, the New Jersey Real Estate Commission, the State Board of Shorthand Reporting, the State Board of Veterinary Medical Examiners, the Radiologic Technology Board of Examiners, the Acupuncture Examining Board, the State Board of Chiropractic Examiners, the State Board of Respiratory Care, the State Real Estate Appraiser Board, the State Board of Social Work Examiners, and the State Board of Software Designers.

(cf: P.L.1991, c.134, s.15)

19. Section 1 of P.L.1974, c.46 (C.45:1-3.1) is amended to read as follows:

1. The provisions of this act shall apply to the following boards and commissions: the New Jersey State Board of Accountancy, the New Jersey State Board of Architects, the New Jersey State Board of Cosmetology and Hairstyling, the Board of Examiners of Electrical Contractors, the New Jersey State Board of Dentistry, the State Board of Mortuary Science of New Jersey, the State Board of Professional Engineers and Land Surveyors, the State Board of Marriage Counselor Examiners, the State Board of Medical Examiners, the New Jersey Board of Nursing, the New Jersey State Board of Optometrists, the State Board of Examiners of Ophthalmic Dispensers and Ophthalmic Technicians, the Board of Pharmacy, the State Board of Professional Planners, the State Board of Psychological Examiners, the State Board of Examiners of Master Plumbers, the State Board of Shorthand Reporting, the State Board of Veterinary Medical Examiners, the Radiologic Technology Board of Examiners, the Acupuncture Examining Board, the State Board of Chiropractic Examiners, the State Board of Respiratory Care, the State Real Estate Appraiser Board, the State Board of Social Work Examiners, and the State Board of Software Designers.

(cf: P.L.1991, c.134, s.17)

20. Section 2 of P.L.1978, c.73 (C.45:1-15) is amended to read as follows:

2. The provisions of this act shall apply to the following boards and all professions or occupations regulated by or through such boards: the New Jersey State Board of Accountancy, the New Jersey State Board of Architects, the New Jersey State Board of Cosmetology and Hairstyling, the Board of Examiners of Electrical Contractors, the New Jersey State Board of Dentistry, the State Board of Mortuary Science of New Jersey, the State Board of Professional Engineers and Land Surveyors, the State Board of Marriage Counselor Examiners, the State Board of Medical Examiners, the New Jersey Board of Nursing, the New Jersey State Board of Optometrists, the State Board of Examiners of Ophthalmic Dispensers and Ophthalmic Technicians, the Board of Pharmacy, the State Board of Professional Planners, the State Board of Psychological Examiners, the State Board of Examiners of Master Plumbers, the State Board of Shorthand Reporting, the State Board of Veterinary Medical Examiners, the Acupuncture Examining Board, the State Board of Chiropractic Examiners, the State Board of Respiratory Care, the State Real Estate Appraiser Board, the State Board of Social Work Examiners, and the State Board of Software Designers.

(cf: P.L.1991, c.134, s.14)

21. This act shall take effect immediately, except that section 9 shall remain inoperative until the 365th day after enactment.

Appendix 12 Text of New Jersey ASME Statement

A New Jersey bill entitled "Software Engineers' Licensing Act" Assembly, No. 4414 would define "licensed software engineer" as "any person who practices software engineering and who represents himself to the public by title or by description of services under any title incorporating such terms as 'software engineer,' 'chartered engineer,' or 'CEng,' ...". The New Jersey Section of the American Society of Mechanical Engineers (ASME) recommends changing the title and certain provisions of the act to recognize the difference between registered Professional Engineers and other non-engineer professionals who would be licensed under the act.

Specifically, the title should be changed to the "Software Engineers and Designers Licensing Act." In addition, the term "licensed software engineer" should only apply to individuals who are licensed under this act and also hold a Professional Engineer's license in the State of New Jersey. All other professionals licensed under the act should be called "licensed software designers."

The main purpose for licensing of engineers in New Jersey and other states is public safety. New Jersey, like other states, licenses Professional Engineers upon satisfactory completion of examinations in various aspects of engineering and meeting certain qualifications of experience and education. Persons who have not been so licensed are not allowed to present themselves as Professional Engineers.

We recognize that computer software used for control, maintenance and emergency operations has significant public safety implications. However, as Assembly Bill No. 4414 now reads, any person may be licensed and designated a "software engineer," regardless of experience, education or examination, who participates in activities defined as creating software systems and techniques... including but not limited to, the elements of requirements engineering, design specification, implementation testing and validation, operation and maintenance and software management. We believe that if those engaged in these activities present themselves as software engineers, they would be in violation of the provisions of state legislation covering the licensing of engineers, unless they have been specifically licensed as Professional Engineers. At a minimum, it would create confusion in the public's mind about the meaning of the term "engineer."

By changing the title of the bill and adding a separate section on licensing of "software designers," the professional standards of the engineering profession would be maintained while allowing for non-engineer software professionals to be licensed under the act.

[This statement was prepared by the New Jersey Section of ASME. It represents the considered judgement of this Section rather than an official position of ASME.]

Appendix 13 Examples of Licensed Occupations

Although licensing is a component of many mature professions, it is not by itself sufficient to cause an occupation to be considered a profession. The tables below demonstrate this fact by listing the occupations that are licensed, certified, registered, or otherwise regulated by the state of California. Clearly, most of these occupations do not match our intuitive idea of a profession.

alarm company operator	*furniture:*	land surveyor
apprentice barber	retail furniture dealer	locksmith
apprentice cosmetologist	custom upholsterer	manicurist
architect	wholesale furniture dealer	*mule racing:*
attorney	furniture manufacturer	trainer
automotive lamp and brake adjuster	retail bedding dealer	jockey
barber	bedding renovator	other participant
barber instructor	wholesale bedding dealer	outdoor advertiser
boxing:	bedding manufacturer	private investigator
professional and amateur boxer	supply dealer	private patrol operator (private security)
professional and amateur martial arts fighter	sanitizer	professional engineer
booking agent	insulation manufacturer	real estate appraiser
manager of professional boxers and professional martial arts fighters	geologist	real estate broker
trainer	geophysicist	repossessor[7]
chief second	guide dog instructor[6]	*structural pest control:*
second	*horse racing:*	operator
certified public accountant	horse owner	field representative
contractor	jockey	applicator
cosmetologist	driver	unlawful detainer assistant[8]
cosmetology instructor	apprentice	
electrologist	exercise boy	
embalmer	agent trainer	
esthetician	observer	
funeral director	stable foreman	
	groom	
	valet	
	horseshoer	
	stable watchman	
	employee of a parimutuel department	

Table A14.1: Licensed Occupations Other Than Healing Arts (California)

[6] a person who instructs blind persons in the use of guide dogs or who engages in the business of training, selling, hiring, or supplying guide dogs for the blind

[7] a person who, for any consideration whatsoever, engages in business or accepts employment to locate or recover personal property, including, but not limited to, personal property registered under the provisions of the Vehicle Code which has been sold under a security agreement

[8] an individual who for compensation renders assistance or advice in the prosecution or defense of an unlawful detainer claim or action, including any bankruptcy petition that may affect the unlawful detainer claim or action

acupuncturist	educational psychologist	podiatrist
child counselor	family counselor	psychiatric technician
clinical chemist	hearing aid dispenser	psychologist
clinical cytogeneticist	marriage counselor	respiratory care practitioner
clinical laboratory bioanalyst	midwife	speech-language pathologist or audiologist
clinical laboratory technologist	nurse	
clinical microbiologist	nursing home administrator	surgeon
clinical molecular biologist	osteopath	veterinarian
clinical social worker	physical therapist	vocational nurse
clinical toxicologist	physician	
dentist	physician's assistant	

Table A14.2: Licensed Healing Arts Occupations (California)

cremated remains disposer	pharmacist	tax preparer
dispensing optician	professional photocopier	
optometrist	psychoanalyst	

Table A14.3: Occupations Requiring Registration (California)

landscape architect	shorthand reporter

Table A14.4: Occupations Requiring Certificates (California)

dietitian	perfusionist	shopping cart retriever
occupational therapist		laundry cart retriever

Table A14.5: Other Regulated Occupations (California)

Appendix 14 Oath of Hippocrates

Translated by Francis Adams

I SWEAR by Apollo the physician, and Aesculapius, and Health, and All-heal, and all the gods and goddesses, that, according to my ability and judgment, I will keep this Oath and this stipulation—to reckon him who taught me this Art equally dear to me as my parents, to share my substance with him, and relieve his necessities if required; to look upon his offspring in the same footing as my own brothers, and to teach them this art, if they shall wish to learn it, without fee or stipulation; and that by precept, lecture, and every other mode of instruction, I will impart a knowledge of the Art to my own sons, and those of my teachers, and to disciples bound by a stipulation and oath according to the law of medicine, but to none others. I will follow that system of regimen which, according to my ability and judgment, I consider for the benefit of my patients, and abstain from whatever is deleterious and mischievous. I will give no deadly medicine to any one if asked, nor suggest any such counsel; and in like manner I will not give to a woman a pessary to produce abortion. With purity and with holiness I will pass my life and practice my Art. I will not cut persons laboring under the stone, but will leave this to be done by men who are practitioners of this work. Into whatever houses I enter, I will go into them for the benefit of the sick, and will abstain from every voluntary act of mischief and corruption; and, further from the seduction of females or males, of freemen and slaves. Whatever, in connection with my professional practice or not, in connection with it, I see or hear, in the life of men, which ought not to be spoken of abroad, I will not divulge, as reckoning that all such should be kept secret. While I continue to keep this Oath unviolated, may it be granted to me to enjoy life and the practice of the art, respected by all men, in all times! But should I trespass and violate this Oath, may the reverse be my lot!

Written circa 400 B.C.

Appendix 15 Principles of Medical Ethics

Copyright 1994, American Medical Association

Preamble:

The medical profession has long subscribed to a body of ethical statements developed primarily for the benefit of the patient. As a member of this profession, a physician must recognize responsibility not only to patients, but also to society, to other health professionals, and to self. The following Principles adopted by the American Medical Association are not laws, but standards of conduct which define the essentials of honorable behavior for the physician.

I. A physician should be dedicated to providing competent medical service with compassion and respect for human dignity.

II. A physician shall deal honestly with patients and colleagues, and strive to expose those physicians deficient in character or competence, or who engage in fraud or deception.

III. A physician shall respect the law and also recognize a responsibility to seek changes in those requirements which are contrary to the best interest of the patient.

IV. A physician shall respect the rights of patients, of colleagues, and of other health professionals, and shall safeguard patient confidences within the constraints of the law.

V. A physician shall continue to study, apply and advance scientific knowledge, make relevant information available to patients, colleagues, and the public, obtain consultation, and use the talents of other health professionals when indicated.

VI. A physician shall, in the provision of appropriate patient care, except in emergencies, be free to choose whom to serve, with whom to associate, and the environment in which to provide medical services.

VII. A physician shall recognize a responsibility to participate in activities contributing to an improved community.

Appendix 16 Code of Ethics of the Idaho Bar Association

Topic Outline

Client Lawyer Relationship
- Rule 1.1 Competence
- Rule 1.2 Scope of Representation
- Rule 1.3 Diligence
- Rule 1.4 Communication
- Rule 1.5 Fees
- Rule 1.6 Confidentiality of Information
- Rule 1.7 Conflict of Interest: General rule
- Rule 1.8 Conflict of Interest: Prohibited Transactions
- Rule 1.9 Conflict of Interest: Former Client
- Rule 1.10 Imputed Disqualification: General Rule
- Rule 1.11 Successive Government and Private Employment
- Rule 1.12 Former Judges, or Arbitrator or Law Clerks
- Rule 1.13 Organization as Client
- Rule 1.14 Client Under a Disability
- Rule 1.15 Safekeeping Property
- Rule 1.16 Declining or Terminating Representation

Counselor
- Rule 2.1 Advisor
- Rule 2.2 Intermediary
- Rule 2.3 Evaluation for Use by Third Person

Advocate
- Rule 3.1 Meritorious Claims and Contentions
- Rule 3.2 Expediting Litigation
- Rule 3.3 Candor Toward the Tribunal
- Rule 3.4 Fairness to Opposing Party and Counsel
- Rule 3.5 Impartiality and Decorum of the Tribunal
- Rule 3.6 Trial Publicity
- Rule 3.7 Lawyer as Witness
- Rule 3.8 Special Responsibilities of a Prosecutor
- Rule 3.9 Advocate in Nonadjudicative Proceedings

Transactions With Persons Other Than Clients
- Rule 4.1 Truthfulness in Statements to Others
- Rule 4.2 Communication with Person Represented by Counsel
- Rule 4.3 Dealing with Unrepresented Person
- Rule 4.4 Respect for Rights of Third Persons

Law Firms and Associations
- Rule 5.1 Responsibilities of a Partner or Supervisory Lawyer
- Rule 5.2 Responsibilities of a Subordinate Lawyer
- Rule 5.3 Responsibilities Regarding Non-lawyer Assistants
- Rule 5.4 Professional Independence of a Lawyer
- Rule 5.5 Unauthorized Practice of Law
- Rule 5.6 Restrictions on Right to Practice

PREAMBLE: A LAWYER'S RESPONSIBILITIES

A lawyer is a representative of clients, an officer of the legal system and a public citizen having special responsibility for the quality of justice.

As a representative of clients, a lawyer performs various functions. As advisor, a lawyer provides a client with an informed understanding of the client's legal rights and obligations and explains their practical implications. As advocate, a lawyer zealously asserts the client's position under the rules of the adversary system. As negotiator, a lawyer seeks a result advantageous to the client but consistent with requirements of honest dealing with others. As intermediary between clients, a lawyer seeks to reconcile their divergent interests as an advisor and, to a limited extent, as a spokesperson for each client. A lawyer acts as evaluator by examining a client's legal affairs and reporting about them to the client or to others.

In all professional functions a lawyer should be competent, prompt and diligent. A lawyer should maintain communication with a client concerning the representation. A lawyer should keep in confidence information relating to representation of a client except so far as disclosure is required or permitted by the Rules of Professional Conduct or other law.

A lawyer's conduct should conform to the requirements of the law, both in professional service to clients and in the lawyer's business and personal affairs. A lawyer should use the law's procedures only for legitimate purposes and not to harass or intimidate others. A lawyer should demonstrate respect for the legal system and for those who serve it, including judges, other lawyers and public officials. While it is a lawyer's duty, when necessary, to challenge the rectitude of official action, it is also a lawyer's duty to uphold legal process.

As a public citizen, a lawyer should seek improvement of the law, the administration of justice and the quality of service rendered by the legal profession. As a member of a learned profession, a lawyer should cultivate knowledge of the law beyond its use for

clients, employ that knowledge in reform of the law and work to strengthen legal education. A lawyer should be mindful of deficiencies in the administration of justice and of the fact that the poor, and sometimes persons who are not poor, cannot afford adequate legal assistance, and should therefore devote professional time and civic influence in their behalf. A lawyer should aid the legal profession in pursuing these objectives and should help the bar regulate itself in the public interest.

Many of a lawyer's professional responsibilities are prescribed in the Rules of Professional Conduct, as well as substantive and procedural law. However, a lawyer is also guided by personal conscience and the approbation of professional peers.

A lawyer should strive to attain the highest level of skill, to improve the law and the legal profession and to exemplify the legal profession's ideals of public service.

A lawyer's responsibilities as a representative of clients, an officer of the legal system and a public citizen are usually harmonious. Thus, when opposing party is well represented, a lawyer can be a zealous advocate on behalf of a client and at the same time assume that justice is being done. So also, a lawyer can be sure that preserving client confidences ordinarily serves the public interest because people are more likely to seek legal advice, and thereby heed their legal obligations, when they know their communications will be private.

In the nature of law practice, however, conflicting responsibilities are encountered. Virtually all difficult ethical problems arise from conflict between a lawyer's responsibilities to clients, to the legal system and to the lawyer's own interest in remaining an upright person while earning a satisfactory living. The Rules of Professional Conduct prescribe terms for resolving such conflicts. Within the framework of these Rules many difficult issues of professional discretion can arise. Such issues must be resolved through the exercise of sensitive professional and moral judgment guided by the basic principles underlying the Rules.

The legal profession is largely self-governing. Although other professions also have been granted powers of self-government, the legal profession is unique in this respect because of the close relationship between the profession and the processes of government and law enforcement. This connection is manifested in the fact that ultimate authority over the legal profession is vested largely in the courts.

To the extent that lawyers meet the obligations of their professional calling, the occasion for government regulation is obviated. Self-regulation also helps maintain the legal profession's independence from government domination. An independent legal profession is an important force in preserving government under law, for abuse of legal authority is more readily challenged by a profession whose members are not dependent on government for the right to practice.

The legal profession's relative autonomy carries with it special responsibilities of self-government. The profession has a responsibility to assure that its regulations are conceived in the public interest and not in furtherance of parochial or self-interested concerns of the bar. Every lawyer is responsible for observance of the Rules of Professional Conduct. A lawyer should also aid in securing their observance by other lawyers. Neglect of these responsibilities compromises the independence of the profession and the public interest which it serves.

Lawyers play a vital role in the preservation of society. The fulfillment of this role requires an understanding by lawyers of their relationship to our legal system. The Rules of Professional Conduct, when properly applied, serve to define that relationship.

Appendix 17 California Standards of Professional Conduct for Accountants

This information is taken from the California Business and Professions Code, Sections 5060-5062.

Article 3.5. Standards of Professional Conduct

5060. The name or names under which a firm may render professional services shall contain, and may be restricted to, the name or last name of one or more of the present or former licensees who were associated with a predecessor person, partnership, or other organization, and whose name or names appear in that predecessor organization.

Nothing in this chapter shall prohibit the right to the continuous use of a firm name registered with the board on or before December 31, 1986.

5061. No person engaged in the practice of public accountancy shall pay a commission to obtain a client, nor shall that person accept a commission for a referral to a client of products or services of others. This section shall not prohibit payments for the purchase of an accounting practice or retirement payments to individuals presently or formerly engaged in the practice of public accounting or payments to their heirs or estates.

5062. A licensee shall issue a report which conforms to professional standards upon completion of a compilation, review or audit of financial statements.

Appendix 18 Model Rules of Professional Conduct of the National Council of Examiners for Engineering and Surveying

Copyright 1980 by National Council of Examiners for Engineering and Surveying.

PREAMBLE

To comply with the purpose of the (identify state, registration statue) which is to safeguard life, health, and property, to promote the public welfare, and to maintain a high standard of integrity and practice, the (identify state board, registration statute) has developed the following "Rules of Professional Conduct." These rules shall be binding on every person holding a certificate or registration to offer or perform engineering or land surveying services in this state. All persons registered under (identify state registration statute) are required to be familiar with the registration statute and these rules. The "Rules of Professional Conduct" delineate specific obligations the registrant must meet. In addition, each registrant is charged with the responsibility of adhering to standards of highest ethical and moral conduct in all aspects of the practice of professional engineering and land surveying.

The practice of professional engineering and land surveying is a privilege, as opposed to a right. All registrants shall exercise their privilege of practicing by performing services only in the areas of their competence according to current standards of technical competence.

Registrants shall recognize their responsibility to the public and shall represent themselves before the public only in an objective and truthful manner.

They shall avoid conflicts of interest and faithfully serve the legitimate interests of their employers, clients, and customers within the limits defined by these rules. Their professional reputation shall be built on the merit of their services, and they shall not compete unfairly with others.

The "Rules of Professional Conduct" as promulgated herein are enforced under the powers and vested by (identify state enforcing agency). In these rules, the word "registrant" shall mean any person holding a license or a certificate issued by (identify state registration agency).

RULES OF PROFESSIONAL CONDUCT

I. REGISTRANTS' OBLIGATION TO SOCIETY

1. Registrants in the performance of their services for clients, employers, and customers, shall be cognizant that their first and foremost responsibility is to the public welfare.

2. Registrants shall approve and seal only those design documents and surveys that conform to accepted engineering and land surveying standards and safeguard the life, health, property, and welfare of the public.

3. Registrants shall notify their employer or client and such other authority as may be appropriate when their professional judgment is overruled under circumstances where the life, health, property, or welfare of the public is endangered.

4. Registrants shall be objective and truthful in professional reports, statements, or testimony. They shall include all relevant and pertinent information in such reports, statements, or testimony.

5. Registrants shall express a professional opinion publicly only when it is founded upon an adequate knowledge of the facts and a competent evaluation of the subject matter.

6. Registrants shall issue no statements, criticisms, or arguments on technical matters which are inspired or paid for by interested parties, unless they explicitly identify the interested parties on whose behalf they are speaking, and reveal any interest they have in the matters.

7. Registrants shall not permit the use of their name or firm name by, nor associate in the business ventures with, any person or firm which is engaging in fraudulent or dishonest business or professional practices.

8. Registrants having knowledge of possible violations of any of these "Rules of Professional Conduct" shall provide the state board information and assistance necessary to the final determination of such violation.

II. REGISTRANTS' OBLIGATION TO EMPLOYER AND CLIENTS

1. Registrants shall undertake assignments only when qualified by education or experience in the specific technical fields of engineering or land surveying involved.

2. Registrants shall not affix their signatures or seals to any plans or documents dealing with subject matter in which they lack competence, nor to any such plan or document not prepared under their direct control and personal supervision.

3. Registrants may accept assignments for coordination of an entire project, provided that each design segment is signed and sealed by the registrant responsible for preparation of that design segment.

4. Registrants shall not reveal facts, data, or information obtained in a professional capacity without the prior consent of the client or employer except as authorized or required by law.

5. Registrants shall not solicit or accept financial or other valuable consideration, directly or indirectly, from contractors, their agents, or other parties in connection with work for employers or clients.

6. Registrants shall make full prior disclosures to their employers or clients of potential conflicts of interest or other circumstances which could influence or appear to influence their judgment or the quality of their service.

7. Registrants shall not accept compensation, financial or otherwise, from more than one party for services pertaining to the same project, unless the circumstances are fully disclosed and agreed to by all interested parties.

8. Registrants shall not solicit or accept a professional contract from a governmental body on which a principal or officer of their organization serves as a member. Con-

versely, registrants serving as members, advisors, or employees of a governmental body or department, who are the principals or employees of a private concern, shall not participate in decisions with respect to professional services offered or provided by said concern to the governmental body which they serve.

III. REGISTRANTS' OBLIGATION TO OTHER REGISTRANTS

1. Registrants shall not falsify or permit misrepresentation of their, or their associates', academic or professional qualifications. They shall not misrepresent or exaggerate their degree of responsibility in prior assignments nor the complexity of said assignments. Presentations incident to the solicitation of employment or business shall not misrepresent pertinent facts concerning employers, employees, associates, joint ventures, or past accomplishments.

2. Registrants shall not offer, give, solicit, or receive, either directly or indirectly, any commission or gift, or other valuable consideration in order to secure work, and shall not make any political contribution with the intent to influence the award of a contract by public authority.

3. Registrants shall not attempt to injure, maliciously or falsely, directly or indirectly, the professional reputation, prospects, practice or employment of other registrants, nor indiscriminately criticize other registrants' work.

Appendix 19 Pennsylvania Engineers' Code of Ethics

This information is taken from section 4.(i) of the Pennsylvania Professional Engineers Registration Law:

> It shall be considered unprofessional and inconsistent with honorable and dignified bearing for an professional engineer or professional land surveyor:
>
> 1. To act for his client or employer in professional matters otherwise than as a faithful agent or trustee, or to accept any remuneration other than his stated recompense for services rendered.
>
> 2. To attempt to injure falsely or maliciously, directly or indirectly, the professional reputation, prospects or business of anyone.
>
> 3. To attempt to supplant another engineer or land surveyor after definite steps have been taken toward his employment.
>
> 4. To compete with another engineer or land surveyor for employment by the use of unethical practices.
>
> 5. To review work of another engineer or land surveyor for the same client, except with the knowledge of such engineer or land surveyor, or unless the connection of such engineer or land surveyor with the work has terminated.
>
> 6. To attempt to obtain or render technical services or assistance without fair and just compensation commensurate with the services rendered: Provided, however, the donation of services to a civic, charitable, religious or eleemosynary organization shall not be deemed a violation.
>
> 7. To advertise in self-laudatory language, or in any other manner, derogatory to the dignity of the profession.
>
> 8. To attempt to practice in any other field of engineering in which the registrant is not proficient.
>
> 9. To use or permit the use of his professional seal on work over which he was not in responsible charge.
>
> 10. To aid or abet any person in the practice of engineering or land surveying not in accordance with the provisions of this act or prior laws.

Appendix 20 ACM Code of Ethics and Professional Conduct

In October 1992, the Association for Computing Machinery (ACM) adopted a code of ethics and professional conduct, the topic-level outline of which is quoted below. A set of guidelines was also released, which helps clarify the code of ethics in terms of contemporary professional practice. At the time of this writing, the full text of the guidelines was available at

URL: gopher://ACM.ORG:70/00%5Bthe_files.constitution%5Dbylaw17.txt.

Preamble

Commitment to professional conduct is expected of every member (voting members, associate members, and student members) of the Association for Computing Machinery (ACM). This Code identifies several issues professionals are likely to face, and provides guidelines for dealing with them. Section 1 presents fundamental ethical considerations, while Section 2 addresses additional considerations of professional conduct. Statements in Section 3 pertain more specifically to the individuals who have a leadership role, whether in the workplace or in a professional organization such as ACM. Guidelines for encouraging compliance with the Code are given in Section 4.

1. General Moral Imperatives

As an ACM member I will...

1.1 Contribute to society and human well-being,

1.2 Avoid harm to others,

1.3 Be honest and trustworthy,

1.4 Be fair and take action not to discriminate,

1.5 Honor property rights including copyrights and patents,

1.6 Give proper credit for intellectual property,

1.7 Access computing and communication resources only when authorized to do so,

1.8 Respect the privacy of others,

1.9 Honor confidentiality.

2. More Specific Professional Responsibilities

As an ACM computing professional I will...

2.1 Strive to achieve the highest quality in both the process and products of professional work,

2.2 Acquire and maintain professional competence,

2.3 Know and respect existing laws pertaining to professional work,

2.4 Accept and provide appropriate professional review,

2.5 Give comprehensive and thorough evaluations of computer systems and their impacts, with special emphasis on possible risks,

2.6 Honor contracts, agreements, and assigned responsibilities,

2.7 Improve public understanding of computing and its consequences.

3. Organizational Leadership Imperatives

As an ACM member and an organizational leader, I will...

3.1 Articulate social responsibilities of members of an organizational unit and encourage full acceptance of those responsibilities,

3.2 Manage personnel and resources to design and build information systems that enhance the quality of working life,

3.3 Acknowledge and support proper and authorized uses of an organization's computing and communication resources,

3.4 Ensure that users and those who will be affected by a system have their needs clearly articulated during the assessment and design of requirements; later the system must be validated to meet requirements,

3.5 Articulate and support policies that protect the dignity of users and others affected by a computing system,

3.6 Create opportunities for members of the organization to learn the principles and limitations of computer systems.

4. Compliance with the Code

As an ACM member, I will...

4.1 Uphold and promote the principles of this Code,

4.2 Agree to take appropriate action leading to a remedy if the Code is violated,

4.3 Treat violations of this code as inconsistent with membership in the ACM.

Appendix 21 IEEE Code of Ethics

The Board of Directors of the Institute of Electrical and Electronics Engineers, Inc., has approved this code of ethics, dated August 1990:

We, the members of the IEEE, in recognition of the importance of our technologies in affecting the quality of life throughout the world, and in accepting a personal obligation to our profession, its members and the communities we serve, do hereby commit ourselves to the highest ethical and professional conduct and agree:

1. to accept the responsibility in making engineering decisions consistent with the safety, health and welfare of the public, and to disclose promptly factors that might endanger the public or the environment;
2. to avoid real or perceived conflicts of interest whenever possible, and to disclose them to affected parties when they do exist;
3. to be honest and realistic in stating claims or estimates based on available data;
4. to reject bribery in all its forms;
5. to improve the understanding of technology, its appropriate application, and potential consequences;
6. to maintain and improve our technical competence and to undertake technological tasks for others only if qualified by training or experience, or after full disclosure of pertinent limitations;
7. to seek, accept, and offer honest criticism of technical work, to acknowledge and correct errors, and to credit properly the contributions of others;
8. to treat fairly all persons regardless of such factors as race, religion, gender, disability, age, or national origin;
9. to avoid injuring others, their property, reputation, or employment by false or malicious action;
10. to assist colleagues and co-workers in their professional development and to support them in following this code of ethics.

Appendix 22 ICCP Code of Ethics

Certified computer professionals, consistent with their obligation to the public at large, should promote the understanding of data processing methods and procedures using every resource at their command.

Certified computer professionals have an obligation to their profession to uphold the high ideals and the level of personal knowledge as evidenced by the Certificate held.

Certified computer professionals have an obligation to serve the interests of their employers and clients loyally, diligently and honestly.

Certified computer professionals must not engage in any conduct or commit any act which is discreditable to the reputation or integrity of the data processing profession.

Certified computer professionals must not imply that the Certificates which they hold are their sole claim to professional competence.

Appendix 23 ICCP Codes of Conduct and Good Practice

The essential elements relating to conduct that identify a professional activity are:

- A high standard of skill and knowledge.
- A confidential relationship with people served.
- Public reliance upon the standards of conduct and established practice.
- The observance of an ethical code.

Therefore, these Codes have been formulated to strengthen the professional status of certified computer professionals.

1. Preamble

1.1: The basic issue, which may arise in connection with any ethical proceedings before a Certification Council, is whether a holder of a Certificate administered by that council has acted in a manner which violates the Code of Ethics for certified computer professionals.

1.2: Therefore, the ICCP has elaborated the existing Code of Conduct which defines more specifically an individual's professional responsibility. This step was taken in recognition of questions and concerns as to what constitutes professional and ethical conduct in the computer profession.

1.3: The ICCP has reserved for and delegated to each Certification Council the right to revoke any Certificate which has been issued under its administration in the event that the recipient violates the Code of Ethics, as amplified by the Code of Conduct. The revocation proceedings are specified by rules governing the business of the Certification Council and provide protection of the rights of any individual who may be subject to revocation of a certificate held.

1.4: Insofar as violation of the Code of Conduct may be difficult to adjudicate, the ICCP has also promulgated a Code of Good Practice, the violation of which does not in itself constitute a reason to revoke a Certificate. However, any evidence concerning a serious and consistent breach of the Code of Good Practice may be considered as additional circumstantial evidence in any ethical proceedings before a Certification Council.

1.5: Whereas the Code of Conduct is of a fundamental nature, the Code of Good Practice is expected to be amended from time to time to accommodate changes in the social environment and to keep up with the development of the computer profession.

1.6: A Certification Council will not consider a complaint where the holder's conduct is already subject to legal proceedings. Any complaint will only be considered when the legal action is completed or it is established that no legal proceedings will take place.

1.7: Recognizing that the language contained in all sections of either the code of conduct of the Code of Good Practice is subject to interpretations beyond those intended, the ICCP intends to confine all Codes to matters pertaining to personal actions of individual

certified computer professionals in situations for which they can be held directly accountable without reasonable doubt.

2. Code of Conduct

2.1: Disclosure: Subject to the confidential relationships between oneself and one's employer or client one is expected not to transmit information which one acquires during the practice of one's profession in any situation which may seriously affect a third party.

2.2: Social Responsibility: One is expected to combat ignorance about information processing technology in those public areas where one's application can be expected to have an adverse social impact.

2.3: Conclusions and Opinions: One is expected to state a conclusion on a subject in one's field only when it can be demonstrated that it has been founded on adequate knowledge. One will state a qualified opinion when expressing a view in an area within one's professional competence but not supported by relevant facts.

2.4: Identification: One shall properly qualify oneself when expressing an opinion outside one's professional competence in the event that such an opinion could be identified by a third party as expert testimony, or if by inference the opinion can be expected to be used improperly.

2.5: Integrity: One will not knowingly lay claims to competence one does not demonstrably possess.

2.6: Conflict of Interest: One shall act with strict impartiality when purporting to give independent advice. In the event that the advice given is currently or potentially influential to one's personal benefit, full and detailed disclosure to all relevant interests will be made at the time the advice is provided. One will not denigrate the honesty or competence of a fellow professional or a competitor, with the intent to gain an unfair advantage.

2.7: Accountability: The degree of professional accountability for results will be dependent on the position held and type of work performed. For instance: A senior executive is accountable for the quality of work performed by all individuals the person supervises and for ensuring that recipients of information are fully aware of known limitations in the results provided. The personal accountability of consultants and technical experts is especially important because of the positions of unique trust inherent in their advisory roles. Consequently, they are accountable for seeing to it that known limitations of their work are fully disclosed, documented and explained.

2.8: Protection of Privacy: One shall have special regard for the potential effects of computer-based systems on the right of privacy of individuals whether this is within one's own organization, among customers or suppliers, or in relation to the general public. Because of the privileged capability of computer professionals to gain access to computerized files, especially strong structures will be applied to those who have used their positions of trust to obtain information from computerized files for their personal gain.

Where it is possible that decisions can be made within a computer-based system which could adversely affect the personal security, work of career of an individual, the system

design shall specifically provide for decision review by a responsible executive who will thus remain accountable and identifiable for that decision.

3. Code of Good Practice

3.1: Education: One has a special responsibility to keep oneself fully aware of developments in information processing technology relevant to one's current professional occupation. One will contribute to the interchange of technical and professional information by encouraging and participating in educational activities directed both to fellow professionals and to the public at large. One will do all in one's power to further public understanding of computer systems. One will contribute to the growth of knowledge in the field to the extent that one's expertise, time and position allow.

3.2: Personal Conduct: Insofar as one's personal and professional activities interact visibly to the same public, one is expected to apply the same high standards of behavior in one's personal life as are demanded in one's professional activities.

3.3: Competence: One shall at all times exercise technical and professional competence at least to the level one claims. One shall not deliberately withhold information in one's possession unless disclosure of that information could harm or seriously affect another party, or unless one is bound by a proper, clearly defined confidential relationship. One shall not deliberately destroy or diminish the value or effectiveness of a computer-based system through acts of commission or omission.

3.4: Statements: One shall not make false or exaggerated statements as to the state of affairs existing or expected regarding any aspect of information technology or the use of computers. In communicating with lay persona, one shall use general language wherever possible and shall not use technical terms or expressions unless there exist no adequate equivalents in the general language.

3.5: Discretion: One shall exercise maximum discretion in disclosing or permitting to be disclosed, or to one's own advantage, any information relating the affairs of one's present or previous employers or clients.

3.6: Conflict of Interest: One shall not hold, assume, or consciously accept a position in which one's interests conflict or are likely to conflict with one's current duties unless that interest has been disclosed in advance to all parties involved.

3.7: Violations: One is expected to report violations of the Code, testify in ethical proceedings where one has expert or firsthand knowledge, and serve on panels to judge complaints of violations of ethical conduct.

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A model is presented that allows the characterization of the maturity of a profession in terms of eight infrastructure components: initial professional education, accreditation, skills development, certification, licensing, professional development, a code of ethics, and a professional society. Several mature professions are examined to provide examples of the nature of these components. The current states of the components of software engineering are described, and predictions are made for the evolution of those components as the profession matures.

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